The UNO-VEN Company

Lemont, Illinois

ENSR

Work Plan for Groundwater Management Zone at the UNO-VEN Refinery, Lemont, Illinois

ENSR Consulting and Engineering

June 1994

Document Number 6941-023-200

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ENSR Consulting
and Engineering

740 Pasquinelli Drive
Westmont, IL 60559
(708) 887-1700
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June 14, 1994

ENSR Project No: 6941-023-200

Mr. Douglas W. Clay, P.E.
Hazardous Waste Branch Manager
Permit Section, Bureau of Land
Illinois Environmental Protection Agency
2200 Churchill Road
Springfield, Illinois 62794-9276

SUBJECT: Work Plan for Groundwater Management Zone at the UNO-VEN Refinery in Lemont, Illinois

Dear Mr. Clay:

ENSR Consulting and Engineering is pleased to submit to the Illinois Environmental Protection Agency (IEPA) three copies of the work plan for the Groundwater Management Zone (GMZ) at the UNO-VEN Refinery in Lemont, Illinois. This work plan describes the methods and procedures for installing additional monitoring wells and piezometers in the vicinity of the stormwater basins (SWBs) and the green coke storage area (GCSA) as requested in the IEPA's letter dated April 11, 1994, Condition Nos. 1 and 2. Please notice that the location of these monitoring wells and piezometers had to be carefully selected due to very complex site conditions which include underground utility and aboveground structures. Any changes to these proposed locations may be extremely difficult to implement.

We trust that these additional monitoring wells and piezometers are adequately responsive to the Agency's approval of GMZ application. Once these wells are installed and developed we will start the quarterly groundwater monitoring and sampling program.

Please review this work plan and provide us your comments. We are currently scheduled to start implementation of the field program the week of July 4, 1994. If you have any questions or need additional information, please call me at (708) 887-1700 or Mr. Lee D. Erchull from UNO-VEN at (708) 257-4324.

Sincerely,

David Meiri

David Meiri, Ph.D., CGWP
Manager, Site Assessment and Remediation

RECEIVED
JUN 16 1994
IEPA - BOL
PERMIT SECTION

Reference No. 94-06-V291

cc: L.D. Erchull/UNO-VEN (4 copies)
C.C. Barnard/UNO-VEN (1 copy)
J.C. Starks/ENSR (1 copy)

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1.0 INTRODUCTION

This Work Plan outlines the scope of work, procedures and equipment, and laboratory analytical methods to implement the Groundwater Management Zone (GMZ) Program in the vicinity of the stormwater basins (SWBs) at the UNO-VEN refinery in Lemont, Illinois. This program is being implemented in accordance with Title 35 of the Illinois Administrative Code (IAC) Part 620.250, "Groundwater Management Zone," and is subject to conditions in Section 620.450, "Alternate Groundwater Quality Standards." The GMZ program was conditionally approved by the Illinois Environmental Protection Agency (IEPA) in its April 11, 1994, letter to UNO-VEN (Appendix A).

The following program has been developed to achieve the conditions outlined in the IEPA letter.

- Install five additional 2-inch-diameter, stainless steel shallow bedrock monitoring wells
- Install four additional 1-inch-diameter, polyvinyl chloride (PVC) shallow bedrock piezometers
- Conduct hydraulic conductivity tests for the newly installed monitoring wells
- Conduct quarterly groundwater monitoring, including sampling and analysis and water level measurements
- Prepare quarterly chemical analysis forms and annual reports

ENSR is proposing to use existing monitoring well PB/MW-1 in the northeastern corner of the GMZ as one of the four proposed piezometers. Monitoring well PB/MW-1, a 2-inch-diameter PVC well screened in the upper bedrock/fill material, was installed near the Blend Center as part of a Leaking Underground Storage Tank (LUST) program.

2.0 BACKGROUND

The following section summarizes background information pertaining to the UNO-VEN refinery and the current geologic and hydrogeologic framework. This section also provides a description of the approved GMZ.

2.1 Site Description

The UNO-VEN facility is a petroleum refining facility that processes crude oil into finished petroleum products such as gasoline, fuel oils, and other miscellaneous products. The UNO-VEN property encompasses approximately 860 acres and is divided into the north and south plant. UNO-VEN's SWB is located along the western boundary of the refinery adjacent to the Illinois and Michigan (I&M) Canal (see Figure 2-1).

The northwest and east SWBs, green coke storage area (GCSA), and treated water basin (TWB) were developed in 1969 from an abandoned quarry. From 1969 to 1976, the SWBs were used as a partial equalization basin. From 1976 to late April 1991, the SWBs were used as a total equalization basin. The facility halted discharge of process wastewaters to the SWBs on April 23, 1991. Process water is now routed directly to the on-site wastewater treatment plant (WWTP). Influent water to the SWBs currently is composed of sanitary wastewaters, utility water, fire water, boiler blowdown, and precipitation runoff. The SWBs currently receive an estimated 1,000 gallons per minute (gpm) of influent; its contents are still processed through the WWTP.

The GCSA, located just east of the SWB, holds coke that is stockpiled from refinery processing. The GCSA also contains a sump, located in the south-central portion of the basin, which receives groundwater, surface water runoff, and some process water from coke washing operations. The sump basin consists of three concrete walls and one quarried bedrock wall with a bedrock floor. A smaller attached concrete basin houses two electric pumps equipped with level flats. The pumps(s) discharge to a process water tank before final discharge to the WWTP. The TWB, located south of the northwest SWB, holds treated water before it is discharged to the adjacent Chicago Sanitary and Ship Canal.

2.2 General Site Geology/Hydrogeology

The geology underlying the vicinity of the UNO-VEN refinery is Paleozoic-age bedrock consisting of dolomites, shales, and sandstones ranging in age from Silurian to Cambrian. On the uplands east of the SWB area, Wisconsin-age glacial deposits overlie Silurian dolomite. In the lowlands of the Des Plaines River, including the SWB area, Silurian dolomite is exposed at or very near ground surface.

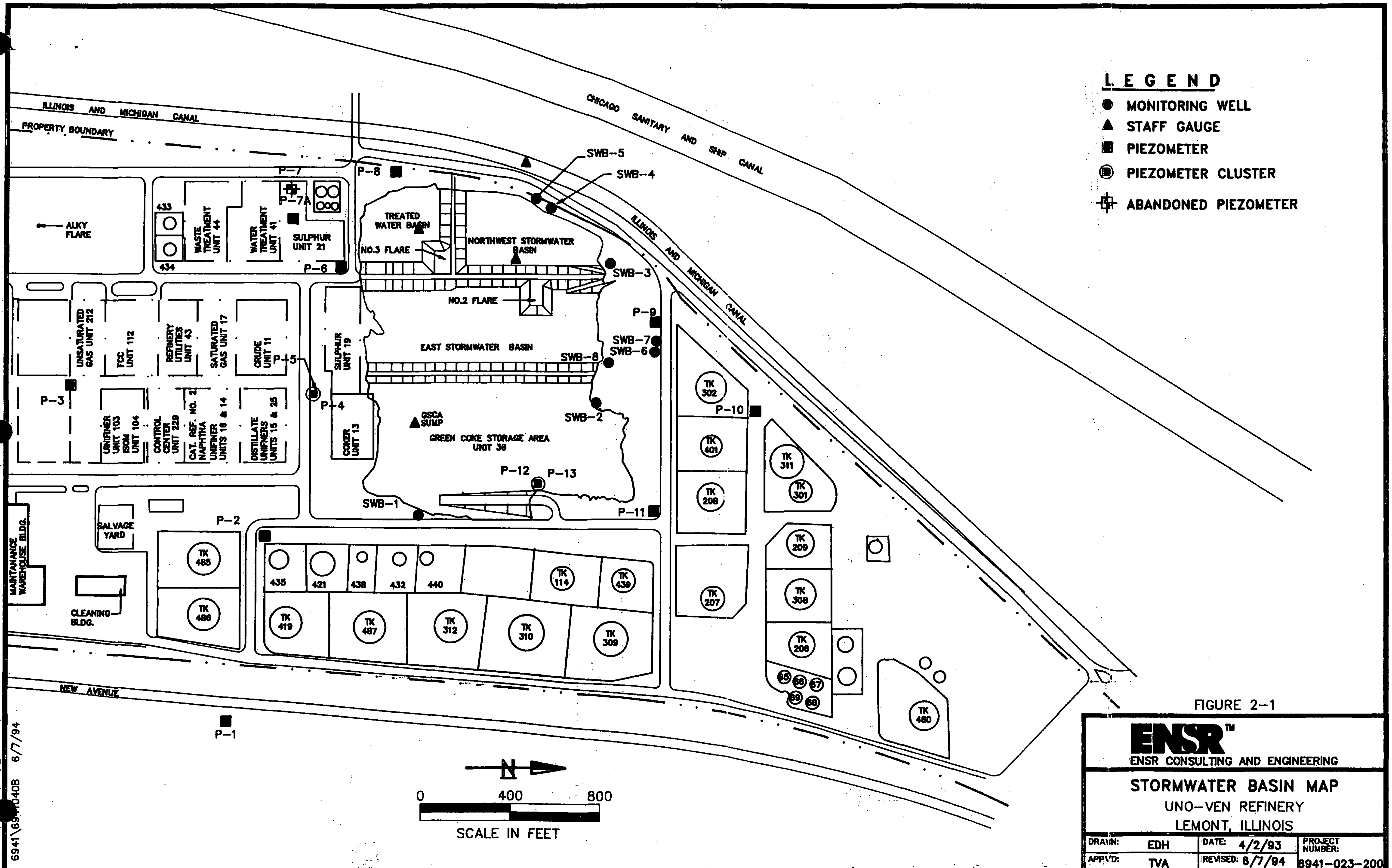
Groundwater is obtained from four aquifer systems in the vicinity of the site: the glacial drift, shallow dolomite, and two deep bedrock aquifer systems (the Cambrian-Ordovician aquifer system and the Mt. Simon sandstone aquifer system). The Mt. Simon sandstone aquifer system of Cambrian age is separated from the overlying Cambrian-Ordovician aquifer system (dolomites and sandstone) by the Eau Claire shale confining beds. Wells at UNO-VEN, which are used as a source of water for shower and toilet facilities, draw from the deep bedrock aquifers.

Groundwater elevations for the dolomite aquifer in the vicinity of the SWBs, under most hydrologic conditions, indicate groundwater flows inward to the SWB and GCSA. During high water conditions however, a slight outward flow toward the Illinois and Michigan Canal can occur. This outward flow condition generally lasts for only a short time following precipitation events because the basins are rapidly dewatered and a radial inward flow is re-established. The basins, particularly the GCSA sump, act as a local sink or discharge area.

2.3 Groundwater Management Zone

A GMZ has been established in the vicinity of the SWBs at the UNO-VEN refinery as a region being managed to mitigate impairment caused by releases of contaminants from the site. IEPA has approved UNO-VEN's existing SWBs and GCSA sump as a corrective action system to pump and treat groundwater in the area around the SWBs. The SWBs and the GCSA sump act as a major sink or drain into which groundwater flows due to continuous pumping from these basins. Water pumped from the basins is treated in UNO-VEN's WWTF with effluent discharged into the TWB. As a result of this pump and treat system, groundwater in the vicinity of the basins is controlled and contained, and the contamination is mitigated. Groundwater samples and water level measurements will be collected on a quarterly basis to monitor the effectiveness of this system.

The GMZ components include the current RCRA alternate groundwater monitoring system around the SWBs and the proposed installation of GMZ monitoring wells and piezometers. The alternate groundwater monitoring system consist of eight stainless steel monitoring wells (SWB-1 through SWB-8); 13 bedrock piezometers (P-1 through P-13); and four staff gauges located in the Illinois and Michigan Canal, northwest SWB, TWB, and GCSA sump.


LEGEND
MONITORING WELL
STAFF GAUGE
PIEZOMETER
PIEZOMETER CLUSTER
ABANDONED PIEZOMETER
ILLINOIS AND MICHIGAN CANAL
PROPERTY BOUNDARY
CHICAGO SANITARY AND SHIP CANAL
NEW AVENUE
ALKY FLARE
WASTE TREATMENT UNIT 44
WATER TREATMENT UNIT 41
SULPHUR UNIT 21
TREATED WATER BASIN
NO.3 FLARE
NORTHWEST STORMWATER BASIN
NO.2 FLARE
EAST STORMWATER BASIN
GSCA SUMP
GREEN COKE STORAGE AREA UNIT 38
UNSATURATED GAS UNIT 212
FCC UNIT 112
REFINERY UTILITIES UNIT 43
SATURATED GAS UNIT 17
CRUDE UNIT 11
SULPHUR UNIT 19
COKER UNIT 13
UNIFINER UNIT 103 ISOM UNIT 104
CONTROL CENTER UNIT 229
CAT. REF. NO. 2 NAPHTHA UNIFINER UNITS 16 & 14
DISTILLATE UNIFINERS UNITS 15 & 25
MAINTANANCE WAREHOUSE BLDG.
SALVAGE YARD
CLEANING BLDG.
P-1
P-2
P-3
P-4
P-5
P-6
P-7
P-7A
P-8
P-9
P-10
P-11
P-12
P-13
SWB-1
SWB-2
SWB-3
SWB-4
SWB-5
SWB-6
SWB-7
SWB-8
433
434
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421
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TK 485
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TK 419
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TK 312
TK 310
TK 309
TK 114
TK 439
TK 302
TK 401
TK 208
TK 207
TK 311
TK 301
TK 209
TK 308
TK 206
TK 480
85
86
87
89
88
N
0
400
800
SCALE IN FEET
ENSR™
ENSR CONSULTING AND ENGINEERING
STORMWATER BASIN MAP
UNO-VEN REFINERY
LEMONT, ILLINOIS
DRAWN: EDH
DATE: 4/2/93
PROJECT NUMBER: 6941-023-200
APP'VD: TVA
REVISED: 6/7/94
6941\6941040B 6/7/94

FIGURE 2-1

3.0 SCOPE OF WORK

This work plan describes the methods and procedures to be used in implementing the GMZ program. The program will include drilling and installation of monitoring wells and piezometers, well development, hydraulic conductivity testing, water level monitoring, and groundwater sampling and analysis.

All work at the UNO-VEN refinery will be conducted in accordance with the site-specific Health and Safety Plan (HASP) provided in Appendix B. Requirements for personnel performing field work described in the HASP (specified in 29 CFR 1910.120[e]) include completion (within the last year) of initial 40-hour training and/or 8-hour refresher training course for work at hazardous waste sites. In addition, all personnel must complete the Three Rivers Safety Council's contractor's safety course and UNO-VEN's on-site contractor's safety program.

3.1 Drilling/Rock Coring

ENSR will install five new shallow bedrock monitoring wells and three shallow bedrock piezometers. The existing monitoring well in the northeastern corner of the GMZ near the Blend Center (PB/MW-1) will be considered the fourth shallow bedrock piezometer and will be known as piezometer P-17. These proposed GMZ monitoring wells and piezometers will supplement the existing network of eight SWB monitoring wells, 13 piezometers, and four staff gauges. The approximate locations of the new monitoring wells (GMZ-1, GMZ-2, GMZ-3, GMZ-4, and GMZ-5) and piezometers (P-14, P-15 and P-16) are illustrated in Figure 3-1. The exact locations of these wells and piezometers will be determined by UNO-VEN following utility clearance.

Prior to drilling at each location, augers, drill bits, drill rods, and other equipment that may enter the borehole will be decontaminated by steam cleaning. In addition, necessary precautions will be taken to prevent the drilling equipment or supplies from exposure to potential contaminants during drilling and sampling operations at each location. Decontamination activities will be conducted in accordance with ENSR Standard Operating Procedure (SOP) No. 7600, provided in Appendix C.

Monitoring well borings will be drilled by first advancing 4.25-inch-inside-diameter (ID) hollow-stem augers or steel casing to a depth of 3 feet into the bedrock surface. Rock coring will be performed in 10-foot runs, as appropriate, utilizing an NX-size core bit and barrel (borehole diameter approximately 3 inches) to an approximate depth of 15 to 20 feet. Coring will be conducted using the water rotary drilling technique. Rock cores will be logged by the supervising geologist and placed in labeled core boxes, which will be kept at the site in a location approved by UNO-VEN. Rock coring activities will be performed in accordance with ENSR's SOP No. 7210, provided in Appendix C.

After completion of rock coring, the monitoring well borings will be enlarged by the water rotary drilling method using a tri-cone drill bit to a diameter of approximately 6 inches. The borings will not be enlarged at the piezometer locations because the borings will be large enough to allow installation of the piezometers. The drilling methods and sequence of drilling locations will be determined based upon conditions encountered at the site.

All boreholes will be flushed with potable water to remove cuttings that may have invaded the adjacent natural formation. Following flushing, the water used to flush the borehole will be evacuated to ensure representative groundwater. Soil and rock cuttings and fluids produced by drilling will be containerized in 55-gallon drums and disposed by UNO-VEN.

3.2 Monitoring Well/Piezometer Installation

The static water levels in the borings will be determined by the supervising geologist. The borings may need to be left undisturbed for a short time (possibly overnight) to allow the static water level to stabilize. The borehole depth may need to be adjusted by further drilling or by filling in the bottom of the borehole with bentonite and sand layers to ensure that the well or piezometer screen will intersect the water table. The final adjusted borehole depth will be approximately 8 feet below the static water level.

Monitoring wells (GMZ-1, GMZ-2, GMZ-3, GMZ-4, and GMZ-5) and piezometers (P-14, P-15, and P-16) will be installed in accordance with ENSR SOP 7220 (Appendix C). Monitoring wells will be constructed of 2-inch-ID, 10-foot-long stainless steel well screen (slot size 0.020 inch), and stainless steel flush-thread jointed riser. The piezometers will be constructed of 1.049-inch ID, 10-foot-long polyvinyl chloride (PVC) screen (slot size 0.02 inch) and PVC riser. The bottom of the borehole and the annular space around the well screen will be sand packed to approximately 2 feet above the screen. A 2-foot seal consisting of bentonite pellets will be installed above the sand pack. The bentonite pellets will be hydrated with potable water and allowed to set before placement of the grout.

A cement-bentonite grout (approximately 95% cement and 5% bentonite by weight) will be pumped by gravity through a tremie pipe or hose to fill the remaining annular space between the riser and the borehole. A locking protective steel well cover, to protect the riser and to prevent using the Bouwer & Rice[1] or Hvorslev[2] method. Calculations of hydraulic conductivity will be performed in accordance with ENSR SOP 1005 (Appendix C). The hydraulic conductivity value obtained from the test will be used to calculate groundwater velocity in the area around the newly installed monitoring wells, and to estimate the travel time of potential contaminants between this area and the basin.

3.5 Water Level Monitoring

Water level monitoring of GMZ-1, GMZ-2, GMZ-3, GMZ-4, and GMZ-5 and piezometers P-14, P-15, P-16, and P-17 will be conducted concurrently with the ongoing RCRA Alternate Groundwater Monitoring Program. Water levels will be measured at the newly installed wells and piezometers, and all stormwater basin monitoring wells, piezometers, and staff gauges on a quarterly basis. The water level measurements will be used to generate a water table contour map, and determine the hydraulic gradient and the groundwater flow direction.

3.6 Groundwater Sampling and Analytical Procedures

Following installation and development of the new monitoring wells, groundwater sampling will be conducted in both the newly installed GMZ monitoring wells and the SWB monitoring wells. This sampling will be conducted concurrently with the ongoing RCRA Alternate Groundwater Monitoring Program. Groundwater sampling will be performed in accordance with ENSR SOP No. 7130 (Appendix C).

The samples will be analyzed for volatile organic compounds (VOCs) using EPA Method 8240[3] and for semivolatile organic compounds (SVOCs) using EPA Method 8270[3]. One duplicate groundwater sample and one field blank (i.e., equipment rinsate) sample will be collected by filling extra sets of sample containers. These quality control samples will be analyzed for VOCs and SVOCs. Also, one trip blank sample will be submitted with each shipping cooler containing VOC samples and analyzed for VOCs.

---

[1]Bouwer, H. and R.C. Rice, 1976. *A Slug Test Method for Determining Hydraulic Conductivity Aquifers With Completely or Partially Penetrating Wells.* Water Resources Research, Vol. 12, No. 3, pp. 423-428.

[2]Hvorslev, M.J. 1951. *Time Lag and Soil Permeability in Groundwater Observation.* Waterways Experiment Station Bulletin No. 36, Vicksburg, Mississippi.

[3]U.S. EPA *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods,* (SW846, 3rd Edition, November 1990.

Prior to groundwater sample collection, each monitoring well will be purged using a decontaminated Teflon™ or stainless steel bailer. At least three well casing volumes will be purged to confirm that all stagnant water has been replaced. The purged water will be monitored after each well casing volume for groundwater pH, temperature, and specific conductance. At least three stable measurements of these parameters will be obtained. However, if three stable measurements cannot be obtained, a maximum of five well casing volumes will be purged prior to sampling. In wells that are purged to dryness once, the monitoring well will be allowed to refill before sampling. Another set of parameter measurements will be collected after the monitoring well refills.

After purging, ENSR will collect a groundwater sample from each well using a Teflon® or stainless steel bailer and new nylon cord. The bailer will be decontaminated prior to each use unless the same bailer used to purge the monitoring well is used for sampling. New or decontaminated nitrile or surgical gloves will be used when handling the sampling equipment.

The sample containers will be labeled at the point of sampling and placed in a cooler with ice. The cooler will be shipped by overnight courier under standard chain-of-custody procedures to Net Laboratories in Bartlett, Illinois. Samples will be shipped in accordance with ENSR SOP No. 7510 (Appendix C).

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ENSR CONSULTING AND ENGINEERING

LOCATION OF PROPOSED AND EXISTING GROUNDWATER MONITORING WELLS
UNO-VEN REFINERY
LEMONT, ILLINOIS

DESIGN: JS	DATE: 2/2/94	DRAWING NUMBER: FIGURE 3-1	
DRAWN: EDH	SCALE: 1 INCH=200 FEET		
CHECKED: DM	APPROVED: X	PROJECT NO. 6941-023-200	SHEET NO. X

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JUN 16 1994
PERMIT SECTION

4.0 REPORTING

Following the monitoring well and piezometer installation program, ENSR will submit a letter report to UNO-VEN documenting the field program. The report will include a description of all on-site activities and a site map showing the locations of the newly installed monitoring wells and piezometers. Boring logs and hydraulic conductivity test results will also be provided.

Following quarterly groundwater sampling, and upon receipt of analytical data, ENSR will complete the IEPA Division of Land Pollution Control's Chemical Analysis Form (LPC/60) and submit the form to IEPA. ENSR will also prepare an annual report to be submitted to the IEPA by March 1 of each year; this report will address the effectiveness of the corrective action program, the validity of the GMZ, and reporting requirements under 35 IAC 725.175 (as they relate to the UNO-VEN refinery). The report will also address the following items:

- The ability of the GMZ program to control groundwater.
- Statistically significant increases or decreases in the quality of groundwater at the facility during operation of the corrective action program.
- Records (in tabular form) of the rate at which water is removed.
- Records of any down time and/or equipment failure in the system.
- Any proposed modifications to the program, made in accordance with procedures outlined in Title 35 IAC 620.450.

5.0 SCHEDULE

Following IEPA review of the work plan, ENSR estimates that approximately 4 weeks will be required for mobilization and installation of the proposed monitoring wells and piezometers (including development) and performance of hydraulic conductivity testing. A letter report will be submitted to UNO-VEN approximately 2 weeks after completion of the field work.

Groundwater sampling will be scheduled concurrently with the RCRA Alternate Groundwater Monitoring Program; approximately 3 days will be required to conduct the sampling.

APPENDIX A

IEPA'S APRIL 11, 1994, GMZ APPROVAL LETTER

State of Illinois
ENVIRONMENTAL PROTECTION AGENCY

Mary A. Gade, Director

2200 Churchill Road, Springfield, IL 62794-9276

217/524-3300

April 11, 1994

Mr. L.D. Erchull
Senior Environmental Specialist
UNO-VEN Company
UNO-VEN Refinery
135th Street and New Avenue
Lemont, Illinois 60439-7761

RE: 1978030004 -- Will County
UNO-VEN Refinery
ILD041550567
Subpart F

The additional information for the Groundwater Management Zone (GMZ) application dated February 15, 1994 and prepared by ENSR Consulting and Engineering has been reviewed by the Agency. The application is approved with the following conditions:

1. The approved Groundwater Management Zone (GMZ) shall run through existing monitoring wells SWB-4 and SWB-5 surrounding the Stormwater Basin (SWB) and the Green Coke Storage Area (GCSA) as well as the five (5) additional monitoring wells proposed to be installed at the facility.

2. Four to five additional monitoring wells and/or piezometers must be installed within the GMZ to demonstrate, along with existing monitoring wells and piezometers at the facility, that groundwater flow is properly controlled and an inward gradient is maintained at the facility on a quarterly basis.

3. The demonstration in Condition #2 above, must be summarized and submitted with the annual report described in Condition #6 below. However, raw data must be reported to the Agency on the attached forms quarterly. It must be noted that if at any time it is indicated that an inward gradient does not exist, additional corrective action will be required.

4. In the event that groundwater flow is not adequately controlled, as determined by groundwater monitoring, UNO-VEN shall:

   a. Notify the Agency in writing within seven (7) days of the date this determination is made;

   b. Take actions as necessary to regain control of the groundwater flow; and

   c. Submit a written report to the Agency within thirty (30) days describing the actions taken to regain control of the groundwater flow.

5. UNO-VEN must submit details of GCSA sump construction and operation to the Agency within thirty (30) days.

6. UNO-VEN shall maintain all equipment associated with the withdrawal and treatment of groundwater withdrawn. Equipment failures must be reported in writing to the Agency within seven (7) days of that failure with a description of actions taken to ensure compliance with the requirements of a GMZ.

7. UNO-VEN must submit a report annually, which discusses the effectiveness of the corrective action program and the validity of the GMZ. This report must be submitted with annual report required under 35 Ill. ADM. Code 72~~4~~5.175 due to the Agency March 1 of every year. The report must address:

   a. The ability of the program to control groundwater;

   b. The statistically significant increase or decrease in the quality of groundwater at the facility during operation of the corrective action program;

   c. Records in tabular form of the rate at which water is removed;

   d. Records of any down time and/or equipment failure in the system; and

   e. Any proposed modifications to the program in accordance with procedures found in 35 Ill. Adm. Code 620.450.

8. Upon completion of the corrective action program and the expiration of the GMZ, the facility will be subject to Class I: Potable Resource Groundwater standards as found in 35 Ill. Adm. Code 620.410.

9. The Agency requests that UNO-VEN submit a Computer Aided Design (CAD) facility map (1 inch = 200 feet) converted into .DXF format delineating:

   a. Waste management units

   b. GMZ boundaries

c. Monitoring wells

d. Piezometers

e. Surface water gauges

f. Two (2) points of location within the facility boundary with latitude and longitude reference points (optional).

If you have any questions regarding this subject, please contact Terri Blake Myers at 217/524-3300.

Sincerely,

Douglas W. Clay, P.E.
Harzardous Waste Branch Manager
Permit Section, Bureau of Land

cc: George Hamper, USEPA Region V
David Meiri, ENSR Consulting and Engineering

APPENDIX B

HEALTH AND SAFETY PLAN

UNO-VEN Company

Lemont, Illinois

Health and Safety Plan for Groundwater Management Zone, UNO-VEN's Chicago Refinery

ENSR Consulting and Engineering

May 1994

Document Number 6941-023-100

HEALTH AND SAFETY PLAN

for the

UNO-VEN Company

Lemont, Illinois

Division No:	72
Date:	May 25, 1994
Project No:	6941-023-100
Document No:	94-05-0174.H&S

Prepared By:	John Angelo	Approved By:	Jeffrey C. Starks
Date:	May 25, 1994	Date:	June 1, 1994

John Angelo

(Health and Safety Manager)

Date: June 9, 1994

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(Cont'd)

LIST OF ATTACHMENTS

LIST OF TABLES

1.0 INTRODUCTION

This site-specific Health and Safety Plan (HASP) has been developed to establish the health and safety procedures required to help minimize potential risk to ENSR and ENSR subcontractor personnel who will potentially be exposed to safety and/or health hazards during the performance of activities associated with the tasks described in Section 3.0 of this document.

This HASP has been written to comply with the requirements of the Occupational Safety and Health Administration's (OSHA's) Hazardous Waste Operations and Emergency Response Standard (29 CFR 1910.120). All activities covered by this HASP must be conducted in complete compliance with all applicable federal, state, and local health and safety regulations. Specific reference is made to the OSHA General Industry Standards (29 CFR 1910), including the Hazardous Waste Operations and Emergency Response Standard and the OSHA Construction Industry Standard (29 CFR 1926). *Personnel covered by this HASP who cannot or will not comply with these requirements will be excluded from site activities.*

To ensure that the HASP has been received and reviewed, all field personnel should sign the "HASP Acknowledgement Form" (Attachment 1) and return it to the project manager prior to starting work activities.

Prior to initiating work and at other times as necessary, all field personnel will attend a pre-entry briefing to review and discuss the various aspects of the HASP, including the hazards posed by the site, site activities, available controls, and emergency response procedures. A "Pre-Entry Safety Meeting Form" (Attachment 2) should be completed and returned to the project manager after the meeting.

The procedures in this plan have been developed based upon current knowledge regarding the specific chemical and physical hazards that are known or anticipated for the operations to be conducted at the UNO-VEN Chicago Refinery. If the activities are changed, an evaluation of the revised activities may be necessary.

2.0 SITE DESCRIPTION AND HISTORY

The UNO-VEN Company owns and operates a petroleum refinery known as the Chicago Refinery in Lemont, Illinois (see Facility Location Map in Attachment 3). The site encompasses approximately 860 acres. The focus of the work activity covered by this HASP is a stormwater basin (SWB) located in the west-central portion of the facility (see Site Layout Map in Attachment 4). The SWB, formed from an abandoned on-site limestone quarry in 1987, consists of two wastewater equalization basins with a capacity of approximately 65 million gallons. Under normal operating conditions, the basins contain 20 to 25 million gallons of liquid and sludge. The water surface is approximately 7 to 8 feet above the basin bottom. The materials of concern in the water and sludge are listed and described in Section 4.0 of this document.

3.0 SCOPE OF WORK

The scope of work covered by this HASP includes activities associated with implementing the groundwater management zone (GMZ) program in the vicinity of the SWBs. The specific tasks to be performed include the following.

Task 1 - Monitoring Well and Piezometer Installation

To accurately assess groundwater quality and water levels in the vicinity of the SWB, five monitoring wells (GMZ-1, GMZ-2, GMZ-3, GMZ-4 and GMZ-5) and three piezometers (P-14, P-15, and P-16) will be installed.

Task 2 - Groundwater Sampling

Groundwater sampling of existing on-site SWB monitoring wells and the newly installed wells will be performed.

Task 3 - Water Level Monitoring

To define groundwater flow in the vicinity of the SWB, water levels at the piezometers and monitoring wells will be measured.

Task 4 - Hydraulic Conductivity Testing

Hydraulic conductivity testing will be performed on monitoring wells GMZ-1, GMZ-2, GMZ-3, GMZ-4, and GMZ-5, and piezometers P-14, P-15, and P-16 (see Site Layout Map in Attachment 4). The testing will be conducted by displacing groundwater in the well using a slug of known volume.

4.0 CHEMICAL HAZARD ASSESSMENT

The following paragraphs provide the chemical hazard assessment for the chemical exposures that could occur as a result of the activities associated with groundwater monitoring of the SWB. This assessment is applicable to all tasks identified in Section 3.0.

Based on analysis of sludge and liquid samples, we have prepared Table 4-1, which lists materials of concern, their ranges of concentrations, and their respective OSHA Permissible Exposure Limits (PELs). The following paragraphs describe the chemical properties and health effects associated with each of the chemicals listed in Table 4-1. The results of previous analyses suggest that the primary materials of concern during performance of the scope of work are benzene, toluene, xylene, and hexachlorobenzene.

4.1 Inorganic Materials

Arsenic exposure by ingestion can cause irritation of the stomach and intestines, with nausea, vomiting, and diarrhea. Chronic arsenic exposure through ingestion or inhalation can manifest itself in many ways, including disturbances of the digestive system, liver damage, and disturbances of the blood, kidneys, and nervous system. Upon contact with the skin, arsenic can cause itching, pigmentation, and cancer. Arsenic is a experimental carcinogen of the mucous membranes and bladder and a carcinogen of the lungs, liver, and skin.

Barium is a silver-white metal that has radioactive isotopes in its decay series. However, the acute hazards posed by barium are associated with ingestion, inhalation, and skin contact with certain barium compounds. The usual symptoms of acute dust exposure to barium compounds include irritation of the eyes, nose, throat, and skin (producing dermatitis). Barium salts are somewhat caustic and may change the pH of aqueous solutions.

Cadmium, a silver-white metal, is a poison by inhalation and subcutaneous routes. Chronic exposure may cause a yellow discoloration of teeth, and lung cancer. Brief exposures to high concentrations of cadmium dust may result in pulmonary edema and death. Fatal concentrations may be inhaled without sufficient discomfort to warn a worker to leave the exposure site.

TABLE 4-1

Materials of Concern

Substance	Range of Concentrations (mg/kg)	Permissible Exposure Limit (PEL) (mg/m^3)
Inorganic Materials		
Arsenic	0.04-16	0.5
Barium	0.2-280	0.5
Cadmium	2.4-3.2	0.2
Chromium	0.2-2,000	0.5
Cobalt	60 - 76	0.05
Hydrogen Sulfide	26.7-324	10**
Lead	0.02-100	0.05
Mercury	0.003-0.1	0.01*
Nickel	4-80	1
Selenium	0.1-10	0.2
Vanadium	0.2-630	0.05
Organic Materials		
Benzene	0.510-77	1**
2-Butanone	0.110	200**
Cresols	11	5**
Ethylbenzene	0.170	100**
Hexachlorobenzene	2,400	NE
Indeno (1,2,3,cd) pyrene	1.4	NE
1-Methyl Naphthalene	0.2-46	NE
2-Methyl Naphthalene	0.2	NE
Naphthalene	22	10**
Phenanthrene	15	NE
Xylene	10	100**
Phenol	4.5	5**
Toluene	1.4-64	100**

*ACGIH Threshold Limit Value (TLV).
NE - Not established.
**ppm.

Chromium, required in trace amounts in the diet, is toxic via external exposures (skin) and through the respiratory route. Di- and tri-valent chromous and chromic compounds represent a low order of toxicity, while hexavalent chromates are associated with lung, nasal, and stomach cancer. Chromic acid is noted for producing slow-healing skin and mucus membrane lesions.

Cobalt toxicity by ingestion is low. Significant exposure symptoms result from skin contact, producing dermatitis and hypersensitivity of the skin. Cobalt is reported as a carcinogen of the connective tissues and lungs.

Hydrogen sulfide (H_2S), although it has a pronounced rotten-egg odor, quickly inhibits the body's ability to recognize it (olfactory fatigue). Thus, this poisonous gas is a serious threat in high concentrations. Aside from producing respiratory and eye irritation, H_2S can cause convulsions, coma, and death through respiratory arrest.

Lead, a soft blue-gray metal, is a cumulative poison. The main routes of exposure are inhalation and ingestion of lead-contaminated materials. Chronic lead exposure may result in red blood cell damage, weakness, lassitude, anorexia, numbness and tingling of extremities, and visual and central nervous system damage.

Mercury is a silvery liquid metal that is highly toxic to the central nervous system and gastrointestinal tract via the inhalation or ingestion exposure routes. After mercury is absorbed, it circulates in the blood and is stored in the liver, kidneys, spleen, and bone. Symptoms of exposure include inflammation of the stomach, tremors, and a dark line on the gums. In more severe cases, convulsive or shaking movements may also occur. Mercury also poses a skin hazard because it can be absorbed through skin. Mercury compounds that combine with one or more organic groups are considered more hazardous because the mobility of mercury increases as a compound.

Nickel produces symptoms of exposure to skin known as "nickel itch." This form of dermatitis occurs briefly in persons conducting nickel plating operations. Other exposed persons may experience some degree of hypersensitivity to nickel upon skin contact. Many nickel compounds are experimental carcinogens via the inhalation route.

Selenium, although another essential trace element in the human diet, can produce toxic effects in higher doses. The respiratory exposure route is of primary concern in the workplace. Selenium is irritating to the respiratory system and eyes upon contact. Selenium is also associated with liver and kidney damage and, in chronic exposures, with neurological abnormalities. It is an experimental liver and thyroid carcinogen.

Vanadium compounds (as dusts) act chiefly to irritate the eyes and respiratory tract. However, responses are acute and never chronic. Vanadium poisoning may produce symptoms including loss of appetite, gastrointestinal disorders, nervous complaints, and cough.

4.2 Organic Materials

Benzene, when inhaled, may cause central nervous system depression or excitement, vertigo, headache, incoherent speech, and a feeling of euphoria. Prolonged exposure may result in leukemia, liver damage, and bone marrow injury. Benzene is a liquid with an aromatic odor detectable at approximately 60 ppm.

2-Butanone, or methyl ethyl ketone, is an irritant and depressant to the central nervous system. Signs and symptoms of exposure include irritation of the eyes and respiratory tract, headache, dizziness, nausea, and inflammation of the skin. No permanent effects have been reported. Methyl ethyl ketone has a sharp/sweet odor detectable at approximately 16 ppm.

Cresol is a mixture of isomeric cresols obtained from the distillation of coal tar. Cresol color varies from colorless to yellowish to yellow-brown. Cresol toxicity is moderate via the oral and inhalation exposure routes. It has a corrosive action on the skin and mucus membranes that may result in dermatitis or burns. Cresol has a phenol-like, irritating odor.

Ethylbenzene exposure may cause central nervous system depression, eye and respiratory tract irritation, dizziness, and headache. Ethylbenzene also represents a dermal hazard because it permeates unprotected skin. Ethylbenzene is a liquid with an oily, solvent odor.

Hexachlorobenzene, used as a fungicide, is a human poison, experimental carcinogen, neoplastigen, and teratogen. Clinical experiments have shown hexachlorobenzene to be mildly toxic by inhalation. Because of the attachment of chlorine to the benzene molecule, hexachlorobenzene may also produce chloracne upon repeated contact with the skin. Chloracne is a symptom marked by red pimples forming at the area of skin contact.

Indeno (1,2,3-cd) pyrene data are limited regarding symptoms of exposure. It is an experimental carcinogen and tumorigen, and some data exist to support its mutagenicity. Because this compound is a large molecule, inhalation exposure in a gaseous state is unlikely unless the chemical is heated. Splashing as a liquid may result in exposure to the eyes, mucous membranes, and skin.

Methyl naphthalene is a colorless liquid that is moderately toxic by ingestion and produces skin irritation. Some research indicates possible health effects upon exposure to 1-methylnaphthalene.

Phenanthrene is a solid in crystal form when isolated from coal tar. It is a poison by intravenous route and is mildly toxic by ingestion. Some research indicates that phenanthrene is an experimental tumerigen and mutagen. Phenanthrene may also cause symptoms of skin sensitization upon exposure in sunlight.

Phenol is highly toxic and readily absorbed through the skin. Acute exposure may cause eye and skin burns, nausea, burning sensation in the respiratory tract, and difficulty breathing. Chronic exposure by inhalation may result in headache, cough, insomnia, nervousness, and weight loss. Phenol has a sweet, tar-like odor detectable at approximately 0.06 ppm.

Toluene exposure by inhalation may cause central nervous system depression, liver damage, and bone marrow suppression. Acute exposure may result in corneal burns and lesions, defatting of the skin, fatigue, headache, and dizziness. Toluene is a liquid and has benzene odor detectable at approximately 1.6 ppm.

5.0 PHYSICAL HAZARD ASSESSMENT

5.1 Specific Hazards, By Task

The following physical hazard assessment has been developed for each task identified in Section 3.0.

Task 1 - Monitoring/Piezometer Well Installation

A drill rig will be used to install five monitoring wells and three piezometers on-site. Drilling activities may involve several hazards, including rupturing underground objects, striking overhead objects, and contact with unguarded rotating equipment. The following procedures should be used to help reduce the potential for physical injury when a drill rig is operating.

- Coordinate drilling with local officials and site representatives to learn the locations of underground utilities and other hazards.
- Maintain a minimum clearance of 10 feet above the drill rig to avoid overhead power lines and other obstructions.
- Remain clear of the operating drill rig; loose clothing may snag in the auger.
- Wear steel-toed footwear, hardhats, and safety glasses.
- Stand upwind from drilling activity to help avoid potential inhalation hazard.
- Cease operation of the drill rig in the event of lightening or a storm.

Task 2 - Groundwater Sampling

The predominant hazard of groundwater sampling is splashing groundwater in the eyes. Section 7.0 addresses personal protective equipment requirements for this task.

Task 3 - Water Level Monitoring

No significant health and safety hazards are anticipated with this task.

Task 4 - Hydraulic Conductivity Testing

No significant health or safety hazards are anticipated with this task.

5.2 General Safety Measures

The following general measures are also required.

- The "buddy system" will be used at all times by all field personnel. No one is to perform on-site activities alone.
- Avoidance of contamination is of the utmost importance. Whenever possible, avoid contact with contaminated (or potentially contaminated) surfaces or materials. Avoid sitting, kneeling, or resting equipment on contaminated surfaces.
- Air monitoring equipment will be protected from water and contamination by bagging.
- Eating, drinking, chewing gum or tobacco, smoking, or any practice that increases the probability of hand-to-mouth transfer of materials is prohibited in the work area.
- Hands and face must be thoroughly washed upon leaving the work area, before eating, drinking, or any other activities.
- Beards or other facial hair that may interfere with respirator fit are prohibited (no exceptions).
- The use of alcohol or drugs is prohibited during field operations.
- Safety equipment described in Section 6.0 will be required for all field personnel unless otherwise approved by the ENSR Health and Safety Manager.

5.3 Heat Stress

The increase in ambient air temperatures and the decrease in body ventilation caused by protective outer wear increases potential for heat casualties. Site personnel will be instructed in the identification of heat stress, first-aid procedures, and the prevention of heat stress.

Identification and Treatment

Heat Exhaustion

- **Symptoms:** Heat exhaustion usually begins with muscular weakness, dizziness, nausea, and a staggering gait. Vomiting is frequent. The bowels may move involuntarily. The victim is *very pale, his skin is clammy*, and he may perspire profusely. The pulse is weak and fast, his breathing is shallow. He may faint unless he lies down. This may pass, but sometimes it remains, and death could occur.

- **First Aid:** Immediately remove the victim to the Contamination Reduction Zone in a shady or cool area with good air circulation. Remove all protective outer wear. Call a physician. Treat the victim for shock. (Make him lie down, raise his feet 6 - 12 inches, and keep him cool and loosen all clothing.) If the victim is conscious, it may be helpful to give him sips of water. Transport victim to a medical facility as soon as possible.

Heat Stroke

- **Symptoms:** Heat stroke is serious heat stress because the body overheats excessively. Body temperatures are often between 107° - 110° F. First there is often pain in the head, dizziness, nausea, oppression, and *the skin is dry, red and hot*. Unconsciousness follows quickly and death is imminent if exposure continues.

- **First Aid:** Immediately move the victim to a cool and shady area in the Contamination Reduction Zone. Remove all protective outer wear and all personal clothing. Lay him on his back with the head and shoulders slightly elevated. It is imperative that the body temperature be lowered immediately. This can be accomplished by applying cold wet towels, ice bags, etc., to the head. Sponge off the bare skin with cool water or rubbing alcohol, if available. The main objective is to cool him without chilling him. Give no stimulants. Transport the victim to a medical facility as soon as possible.

Prevention of Heat Stress

- One of the major causes of heat casualties is the depletion of body fluids. On the site, there will be plenty of fluids available. Personnel should replace fluids with water or commercial mixes such as Gatorade. Commercial mixes are advised for personnel on low sodium diets.

- A work schedule should be established so that the majority of the work day will be during the morning hours before ambient air temperature levels rise.

Other methods to prevent heat stress include:

- Proper diet, exercise, and sleep
- Acclimatization
- Restricted alcohol consumption after working hours
- Reduction of personal protection equipment

Heat Stress Monitoring

To monitor the body's ability to cope with excessive heat, one or more of the following screening techniques should be used. Commence monitoring of personnel wearing protective clothing when the ambient temperature is 70°F or above. Frequency of monitoring should increase as the ambient temperature rises or if slow recovery rates are expected. When temperatures exceed 80°F, workers must be monitored for heat stress after every work period.

- **Heart rate** should be measured by radial pulse for 30 seconds as early as possible in the resting period. The heart rate should not exceed 110 beats per minute at the beginning of the rest period, and if it is higher, the next work period should be shortened by 10 minutes (or 33 percent), but the rest period should be left the same. If the pulse rate is 100 beats per minute at the beginning of the next rest period, the following work cycle should be shortened by 33 percent.

- **Body temperature** should be measured orally with a clinical thermometer as early as possible in the resting period. Oral temperature should not exceed 99°F at the beginning of the rest period. If it does, the next work period should be shortened by 10 minutes (or 33 percent), but the rest period should be left the same. However, if the oral temperature exceeds 99.7°F at the beginning of the next period, the following work cycle should be further shortened by 33 percent. The oral temperature should be measured again at the end of the rest period to make sure that it has dropped below 99°F.

- **Body water loss** due to sweating should be measured by weighing the worker in the morning and in the evening. The clothing worn should be similar at both weighings; preferably the worker should be nude. The scale should be accurate to plus or minus 1/4 lb. Water loss should not exceed 1.5 percent of the total body weight, and if it does, workers should be instructed to increase their daily intake of fluids by the weight lost.

See Attachment 5 for more information about exposure to extreme heat.

6.0 AIR SAMPLING AND AIR MONITORING

Air monitoring should be performed for all activities covered under this HASP where there is the potential for air contamination by volatile organic compounds (VOCs). Air monitoring should be conducted initially for Tasks 1 and 2 to determine if, and what type of, respiratory protection is required. If initial air monitoring levels do not exceed the action levels described below, respiratory protection is not required. However, if site activities change and the potential for airborne VOCs is increased, air monitoring should resume.

Air monitoring should be conducted at least initially for Tasks 1 and 2 using a portable photoionization detector (PID), organic vapor analyzer (OVA) or equivalent instrument. Air monitoring for benzene using calorimetric indicator tubes should also be performed to characterize airborne benzene levels. Calorimetric indicator tubes should be used whenever the VOC concentration exceeds 1 unit. The table below provides the action levels for VOCs and benzene and the required level of respiratory protection.

Level of Protection	Airborne Benzene Level (ppm)	Airborne VOC Level (units)
Level D	<1	0-10
Level C (half-mask)	1-10	11-50
Level C (full-face)	1-25	51-100

Representative personal air sampling will also be performed to determine the 8-hour time-weighted average during the sludge and liquid sampling activities. ENSR will use organic vapor badges to assess the airborne exposure to benzene, toluene, xylene, and ethylbenzene.

7.0 PERSONAL PROTECTIVE EQUIPMENT

The following personal protective equipment items are required for each listed task. The level of respiratory protection required is dependent on air monitoring results.

Task 1 - Monitoring Well Installation

_X_ Steel-toed boots
_X_ Hardhat
_X_ Safety glasses
_X_ Canvas or leather gloves
_X_ Tyvek® coveralls
_X_ Nitrile outer gloves (for handling contaminated equipment or soil)
_X_ Air-purifying respirator (if needed)
_X_ Silvershield® inner gloves
_X_ Nomex® coveralls

Task 2 - Groundwater Sampling

_X_ Steel-toed boots
_X_ Hardhat
_X_ Safety glasses
_X_ Nitrile outer gloves
_X_ Polycoated Tyvek® coveralls
_X_ Silvershield® inner gloves
_X_ Nomex® coveralls

Task 3 - Water Level Monitoring

- X Steel-toed boots
- X Safety goggles
- X Nitrile outer gloves
- X Silvershield® inner gloves
- X Nomex® coveralls
- X Hardhat

Task 4 - Hydraulic Conductivity Testing

- X Steel-toed boots
- X Safety goggles
- X Nitrile outer gloves
- X Silvershield® inner gloves
- X Nomex® coveralls
- X Hardhat

If required (indicated by air monitoring results - see Section 6.0), the following respiratory protection will be worn:

- Level C: MSA half-mask air-purifying respirators with GMC-H cartridges or equivalent;
- Level C: MSA full-face air-purifying respirators with GMC-H cartridges or equivalent; or
- Level B: MSA pressure-demand self-contained breathing apparatus (SCBA) equipment or an air-line system equipped with full facepieces operating in the pressure-demand mode and equipped with emergency egress units.

Air-supplied respiratory protection is not anticipated for the tasks described in Section 3.0. Should Level B respiratory protection be required, field staff will immediately contact the Regional Health and Safety Manager for further instruction.

All personnel who will be required to don air-purifying respirators must have been qualitatively or quantitatively fit-tested within the last year for the particular brand and size respirator he/she will be wearing on-site. Normal eyeglasses cannot be worn under full-face respirators because the temple bars interfere with the face seal. For workers requiring corrective facepiece lenses, special spectacles designed for use with respirators must be worn when using a respirator.

8.0 SITE CONTROL

To prevent exposure of unprotected personnel and migration caused by tracking by personnel or equipment, work areas, as indicated below, will be established.

Designation of Zones

Work areas or zones should be designated as suggested by the *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities*, (NIOSH/OSHA/USCG/EPA, November 1985). The guidance manual recommends that the vicinity around each of the work areas be divided into three zones:

- Exclusion or "hot" zone;
- Contamination reduction zone; and
- Support zone.

Exclusion Zone

The exclusion zone will consist of the immediate active work areas where monitoring well installation and groundwater sampling are taking place. The zones will be large enough to prevent unprotected personnel from contacting dusts or vapors from these operations. The perimeter of the exclusion zone will be visibly marked and may be relocated according to work activity. All personnel entering this zone must wear the prescribed level of protective equipment.

Contamination Reduction Zone

The contamination reduction zone, where personnel begin the sequential decontamination process when exiting the exclusion zone, will be located between the exclusion and support zones. To prevent cross-contamination, and for accountability purposes, all personnel will enter and leave the exclusion zone through the contamination reduction zone. It is anticipated that a contamination reduction zone for the SWB sampling will be located on-shore where equipment and sample jars are decontaminated. To avoid tracking potentially contaminated material off-site, gloves and Tyvek® coveralls should be removed when leaving the contamination reduction zone.

Support Zone

The support zone will consist of those areas around the exclusion zone where equipment is staged. Eating and drinking in work areas will be allowed only in this zone. Support vehicles are permitted on uncontaminated portions of the site, but should remain at least 50 feet upwind of the exclusion zone. Vehicles may be placed in the exclusion zone during sampling activities.

9.0 DECONTAMINATION PROCEDURES

Proper decontamination is required of all personnel and equipment before leaving the exclusion zone. Personal decontamination will be accomplished by following a systematic procedure of cleaning and removing personal protective equipment (PPE). Contaminated PPE, such as boots and hardhats, will be rinsed free of heavy amounts of soil, scrubbed in a detergent solution, then rinsed clean. Persons coming in contact with materials suspected or known to be contaminated will wash contaminated equipment prior to leaving the exclusion zone.

Respirators will be cleaned after each use with respirator wipe pads and will be stored in plastic bags after cleaning. Alternative chemical decontamination procedures, such as steam cleaning field boots, may be used if available. Decontamination procedures should be carried out in the following order:

1. Remove and wipe clean hardhat.

2. Decontaminate boots and gloves.

   - Rinse off heavy amounts of soil.
   - Scrub clean.
   - Rinse.

3. Remove outer disposable boots (if worn).

4. Remove outer gloves.

5. Remove Tyvek® coveralls.

6. Remove respirator, wipe clean, and store properly.

7. Remove inner gloves (if worn).

Boots that have been decontaminated can be worn into the support zone.

Prior to steam-cleaning or high-pressure washing of drilling equipment and associated tools, PPE, and vehicles, measurements for VOCs will be taken near the surface of the equipment. If VOC measurements are 1 unit or greater, the equipment will be allowed to aerate prior to decontamination.

Steam cleaning of equipment during decontamination involves risk of steam burns. Employees will wear canvas or leather gloves to help prevent burns.

10.0 MEDICAL MONITORING/TRAINING REQUIREMENTS

All personnel performing activities covered by the HASP must be active participants in program that complies with 20 CFR 1910.120(f). Each individual must have completed an annual surveillance examination and/or an initial baseline examination within the last year before performing any work on the site covered by this HASP. In addition, all personnel must complete both the Three Rivers Safety Council contractors safety orientation course and UNO-VEN's Health and Safety training programs to be allowed to work at the UNO-VEN facility.

All personnel performing activities on the site covered by this HASP must also have the appropriate training requirements specified in 29 CFR 1910.120(e). Each individual must have completed an annual 8-hour refresher training course and/or initial 40-hour training course within the last year. Also, on-site managers and supervisors directly responsible for supervising individuals engaged in hazardous waste operations must have completed the specified 8-hour managers' training course.

All ENSR subcontractor personnel must provide specific written documentation that each individual assigned to this project has completed the medical monitoring and training requirements specified above. This information must be provided prior to the subcontractor's performance of any work on-site.

Prior to the commencement of on-site investigative activities, a site safety meeting will be held to review the specific requirements of this HASP. HASP safety certification forms will be collected at this meeting. Safety refresher meetings will be conducted, as needed, throughout the duration of the project to update field personnel of changes regarding health and safety to inform new field personnel of the health and safety concerns when working on the UNO-VEN site.

11.0 PERSONNEL AND RESPONSIBILITIES

Health and safety responsibilities at this site are integrated among the on-site supervisors, the Project Manager (PM), the appointed on-site Health and Safety Coordinator (HSC), UNO-VEN Health and Safety staff, Field Personnel (FP), and subcontractors on-site.

Project Manager

The PM is, by designation, the individual who has the primary responsibility for ensuring the overall health and safety of this project. The PM therefore has the primary responsibility for ensuring the implementation of the requirements of this HASP. Some of the PM's specific responsibilities include:

- Assuring that all on-site personnel have received a copy of and read this HASP and have completed the HASP sign-off sheet.
- Assuring that prior to performing work on the site all personnel have attended a briefing apprising them of the contents of the HASP and site-specific hazards.
- Assuring that sufficient personal protective equipment (PPE) as required by this HASP is available on-site.
- Assuring that all on-site contractors and subcontractor personnel have documentation of employee participation in a medical monitoring program and training program.
- Maintaining a high level of health and safety consciousness among employees at the work site.
- Maintaining regular communications with the HSC and UNO-VEN.

On-Site Health and Safety Coordinator

The appointed HSC will be a member of the project field team. The HSC is responsible for enforcing the requirements of this HASP once on-site work begins. By design, the HSC has the authority to immediately correct all situations where noncompliance with this HASP is noted and to immediately stop work in cases where an immediate danger is perceived. Some of the HSC's specific responsibilities include:

- Procuring and distributing the PPE needed for this project.
- Procuring the air monitoring instrumentation required and performing air monitoring.
- Verifying that all PPE and health and safety equipment is in good working order.
- Setting up and maintaining the personal decontamination facility.
- Notifying the PM of all noncompliance situations and immediate danger situations.
- Supervising and monitoring the safety performance of all personnel to ensure that required safety and health procedures are followed and correcting any deficiencies.
- Conducting accident/incident investigations and preparing accident/incident investigation reports.
- Initiating emergency response procedures.

Field Personnel

All FP are responsible for following the health and safety procedures specified in this HASP and for performing their work in a safe and responsible manner. Some of the specific responsibilities of the FP are as follows:

- Obtaining a copy of the HASP and reading it in its entirety prior to the start of on-site work.
- Bringing forth any questions or concerns regarding the content of the HASP to the PM prior to the start of work.

- Reporting all accidents and incidents to the PM.
- Complying with the requests of the appointed HSC.

12.0 EMERGENCY RESPONSE

OSHA defines emergency response as any "response effort by employees from outside the immediate release area or by other designated responders (e.g., mutual-aid groups, local fire departments) to an occurrence which results, or is likely to result, in an uncontrolled release of a hazardous substance."

The basic elements of an emergency evacuation plan include employee training, alarm systems, escape routes, escape procedures, critical operations or equipment, rescue and medical duty assignments, designation of responsible parties, emergency reporting procedures, and methods to account for all employees after evaluation.

Employee Training

Employees must be instructed by UNO-VEN in the specific aspects of emergency evacuation applicable to the site as part of the site safety meeting prior to the commencement of all on-site activities. On-site refresher or update training is required any time escape routes or procedures are modified or personnel assignments are changed.

Alarm Systems/Emergency Signals

An emergency communication system must be in effect at all sites. The most simple and effective emergency communication system in many situations will be direct verbal communications. The SWB work area must be assessed at the time of initial site activity and periodically as the work progresses to ensure that the effectiveness of verbal communications will not be compromised. Verbal communications must be supplemented any time voices cannot be clearly perceived above ambient noise levels (e.g., aerators, plant operations, pumps) and any time a clear line-of-sight cannot be easily maintained between personnel because of distance, terrain, or other obstructions.

UNO-VEN emergency signals have been developed in the event of an on-site emergency. The signals are as follows:

- Ten 1-second horn blasts - indicate a fire or potential fire hazard exists on-site.
- One 10-second horn blast - indicates an injury on-site.
- Three 3-second horn blasts - indicates a conditional all clear condition exists on-site.
- Thirty 1-second horn blasts - indicates total or partial evacuation of the site.

Escape Routes and Procedures

Escape routes and procedures for escape should be established for the SWB area prior to working on-site. A map of the site is included in Attachment 6. This HASP and, separately, the facility map, should be posted in an easily accessible and visible location where they may be used by on-site personnel as reference guides. Should an emergency occur on-site, personnel will assemble at the closest exit of the UNO-VEN site following evacuation.

Employee Accounting Method

The on-site field manager is responsible for identifying all personnel in the work area at all times. This can be done informally as long as accurate accounting is kept.

Critical Operations or Equipment

All general and equipment operations are required to cease in accordance with the established signaling procedure. The only exception will be activities related to health and safety. The field manager or HSC must determine at the time of an emergency when health and safety will be jeopardized by immediate stoppage of a particular activity or piece of equipment. If such a determination is made, the number of personnel involved in these critical duties must be minimized and special instructions must be established.

Rescue and Medical Duty Assignments

The phone numbers of the police and fire departments, ambulance service, and local hospital are provided in the emergency reference sheet at the end of this section. Directions to the UNO-VEN first aid facility should be posted in all on-site vehicles that may be used for emergency transport.

Prior to initiating work at the UNO-VEN site, a field team member, usually the HSC, will be appointed to activate emergency response actions. In the event of an injury or illness, first aid requires a coworker to accompany the injured person to the UNO-VEN first aid station and to remain with the person until released.

Designation of Responsible Parties

The individuals responsible for coordination of all emergency response activities are the on-site field manager and the designated HSC. All on-site personnel are responsible for compliance with this HASP and all applicable health and safety regulations.

Emergency Reporting Procedures

In addition to the reporting requirements described above under "Rescue and Medical Duty Assignments," the following reporting is required.

Any incident (other than minor first aid treatment) resulting in injury, illness, or property damage requires an accident investigation and report. The investigation will be initiated as soon as emergency conditions are under control. The purpose of this investigation is not to attribute blame but to determine the pertinent facts so that similar occurrences can be avoided.

The investigation should begin while details are still fresh in the mind of anyone involved. The person administering first aid may be able to begin the fact-gathering process if the injured are able to speak. Pertinent facts must be determined. Questions, beginning with who, what, when, where, and how, are usually most effective to discover ways to improve job performance in terms of efficiency, quality of work, as well as safety and health concerns.

Attached to this plan is a "Supervisor's Accident/Incident Investigation Report" (Attachment 6). This should be submitted within 48 hours after the incident so that a determination may be made as to whether the injury is OSHA reportable or recordable.

First Aid Procedures

The following procedures have been developed to assist field and first aid personnel in administering first aid in the event of chemical exposure.

- **Eye Contact**: If splashed into the eyes, flush with clear water for 15 minutes or until irritation subsides. If irritation persists, call a physician.

- **Skin Contact**: In case of skin contact, remove any contaminated clothing and wash skin thoroughly with soap and water.
- **Inhalation**: If overcome by vapor, remove from exposure and call a physician immediately. If breathing is irregular or has stopped, start resuscitation, and administer oxygen, if available.
- **Ingestion**: If ingested, DO NOT induce vomiting; call a physician immediately.

Emergency Reference

These emergency telephone numbers and directions must be posted conspicuously on-site.

Ambulance:	In-plant	222
Police:	In-plant	222
Fire:	In-plant	222

First Aid:	Emergency first aid provided by UNO-VEN
Hospital:	Silver Cross Hospital 1700 Maple Road Joliet, IL 60432 815/740-1100
Directions to Hospital:	Take Route 171 south through Lockport to Division Street. Turn left onto Division Street. At the blinking yellow light, turn right onto Briggs Road. Take Briggs Road south and turn right onto Route 6, which is Maple Road (see Hospital Route Map, Attachment 7.).
Poison Control Center:	1/800/942-5969
JULIE:	1/800-892-0123
Client Representative:	Lee Erchull 257-4324
Nearest Phone:	Prior to start of work, locate the nearest telephone that can be used in an emergency.

ATTACHMENT 1

HEALTH AND SAFETY PLAN ACKNOWLEDGEMENT FORM

Acknowledgement Form
HEALTH AND SAFETY PLAN

for the GMZ Program

UNO-VEN Site

Located in

Lemont, IL

Document No.: *6941-023-100*

Date: *May 25, 1994*

ISSUED TO:

________________________ ________________________

(Name and Title) *(Representing)*

I have received a copy of the ENSR Health and Safety Plan for this project and I have read and understand its purpose and scope.

____

Signature

____

Date

NOTE: The following information is requested in the event of an emergency.

Special Medical Conditions or Allergies: ________________________

Current Medications: ________________________

Person(s) to be Notified (Name and Telephone Number) ________________________

ATTACHMENT 2

PRE-ENTRY SAFETY MEETING FORM

PRE-ENTRY SAFETY MEETING
UNO-VEN GMZ Program
Lemont, Illinois

Date: ______________

Attended by:

Name	Signature

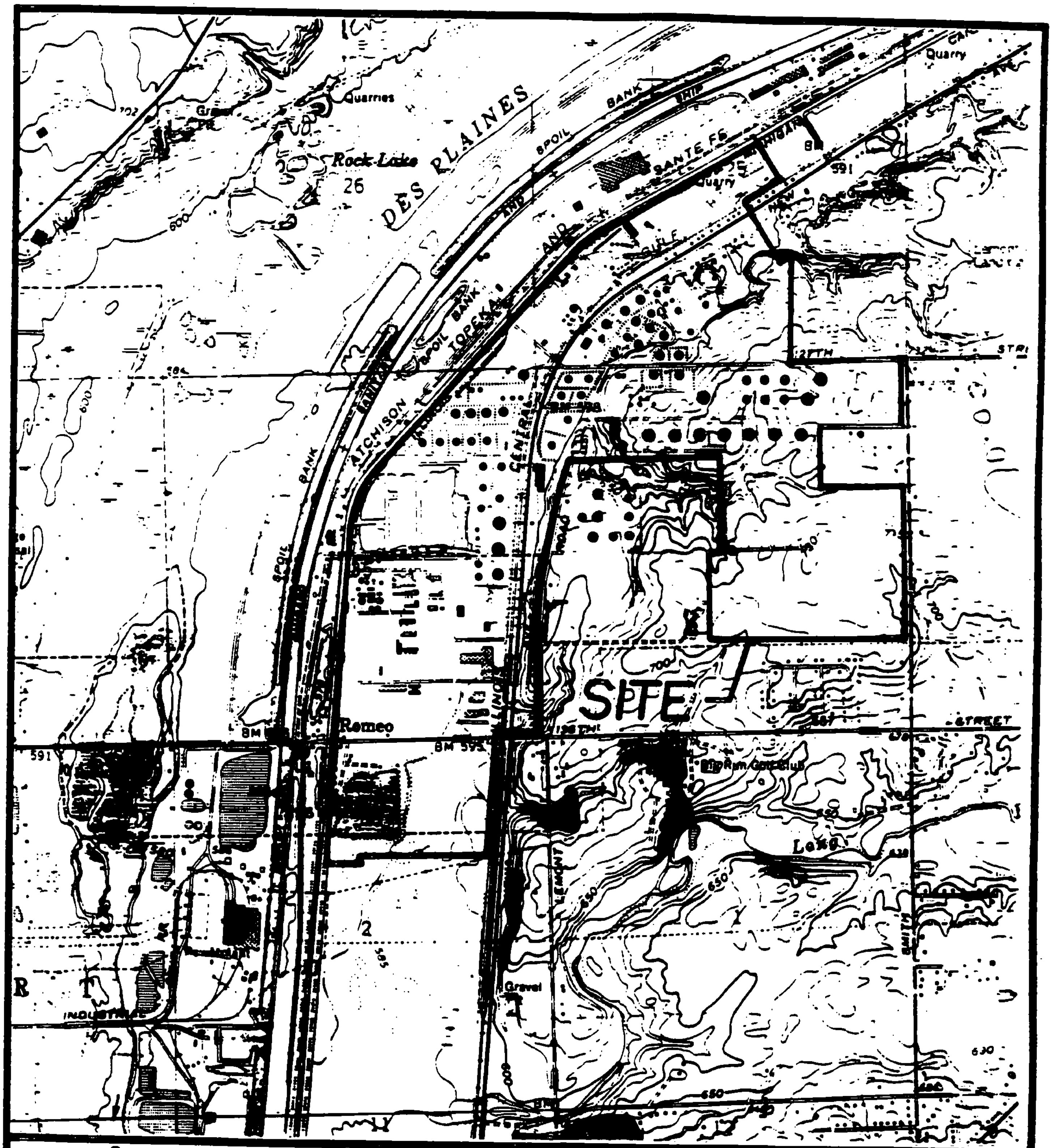
Topic(s) covered:

Conducted by:

____

ATTACHMENT 3

FACILITY LOCATION MAP



0 1

SCALE IN MILES

Ref.: USGS Map, Romeoville, IL. Quadrangle, 1962, Photorevised 1973 and 1980.

ILLINOIS

QUADRANGLE LOCATION

N

ENSR™

ENSR CONSULTING AND ENGINEERING

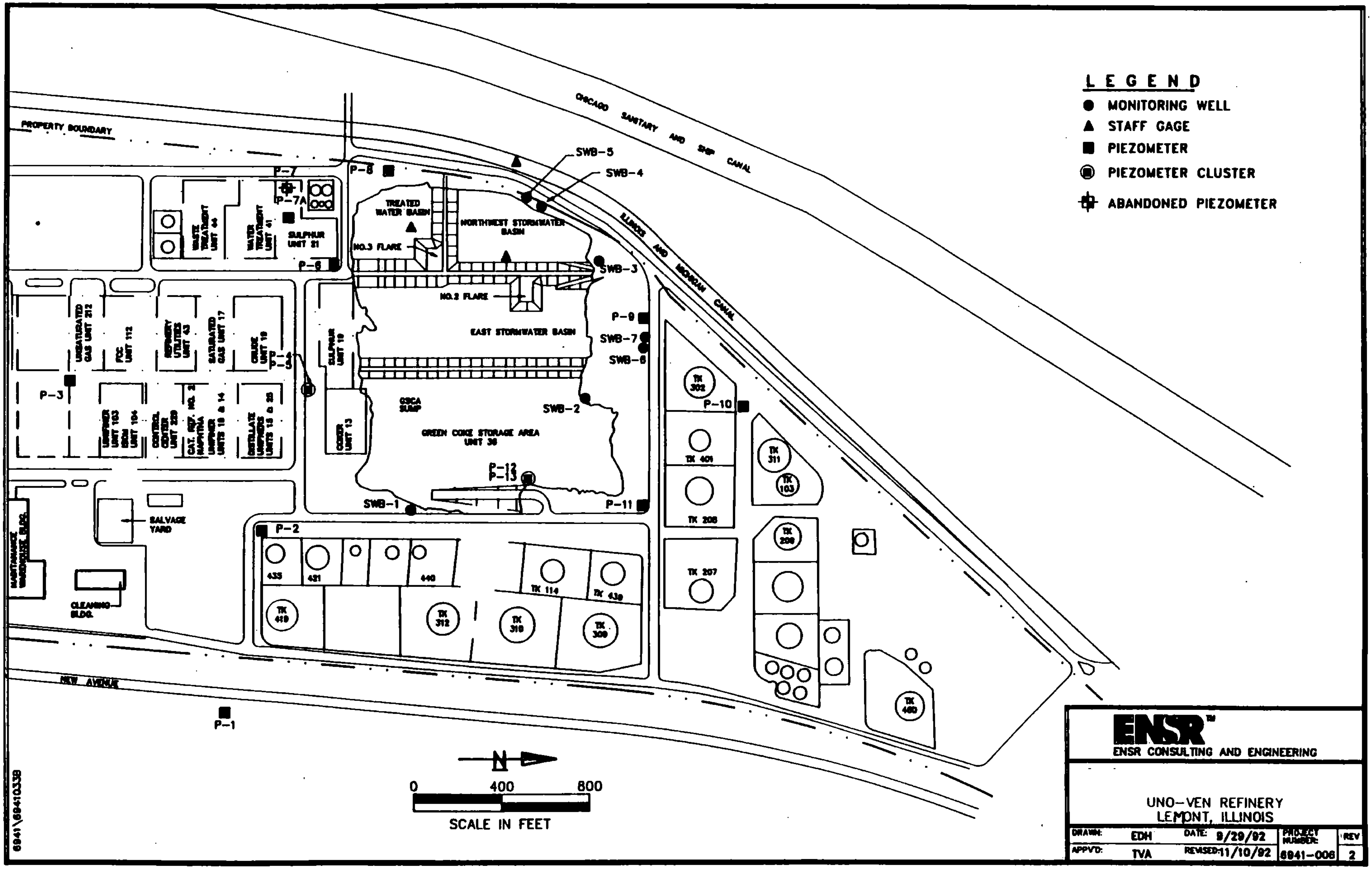
FACILITY LOCATION MAP

UNO-VEN FACILITY
LEMONT, ILLINOIS

DRAWN: EDH	DATE: 4/15/91	PROJECT NUMBER:	REV.
APPV'D:	REVISED:	6941-009	0

ATTACHMENT 4

SITE LAYOUT MAP


LEGEND
MONITORING WELL
STAFF GAGE
PIEZOMETER
PIEZOMETER CLUSTER
ABANDONED PIEZOMETER
CHICAGO SANITARY AND SHIP CANAL
ILLINOIS AND MICHIGAN CANAL
PROPERTY BOUNDARY
NEW AVENUE
TREATED WATER BASIN
NORTHWEST STORMWATER BASIN
NO.3 FLARE
NO.2 FLARE
EAST STORMWATER BASIN
GSCA SUMP
GREEN COKE STORAGE AREA UNIT 36
SULPHUR UNIT 21
SULPHUR UNIT 19
COKER UNIT 13
SALVAGE YARD
MAINTENANCE WAREHOUSE BLDG.
CLEANING BLDG.
P-1
P-2
P-3
P-4
P-6
P-7
P-7A
P-8
P-9
P-10
P-11
P-12
P-13
SWB-1
SWB-2
SWB-3
SWB-4
SWB-5
SWB-6
SWB-7
TK 302
TK 401
TK 206
TK 207
TK 311
TK 103
TK 209
TK 460
TK 419
TK 312
TK 318
TK 309
TK 114
TK 439
0 400 800
SCALE IN FEET
N
ENSR CONSULTING AND ENGINEERING
UNO-VEN REFINERY
LEMONT, ILLINOIS
DRAWN: EDH
DATE: 9/29/92
APPV'D: TVA
REVISED: 11/10/92
PROJECT NUMBER: 6941-006
REV 2
6941\6941033B

ATTACHMENT 5

HEAT STRESS: CAUSES AND RESPONSES

	Type of Heat Stress	Symptoms of Exposure	Predisposing Factors	Underlying Physiological Disturbance	Treatment	Prevention
1.	Heat Stroke and Heat Hyperpyrexia	Heat Stroke: 1) Hot dry skin: red, mottled or cyanotic. 2) High and rising core temperature, 105°F and over. 3) Brain disorders: Mental confusion, loss of consciousness, convulsions, coma as core temperature continues to rise. Fatal if treatment delayed. Heat Hyperpyrexia: milder form. Core temperature lower, less severe brain disorders, some sweating.	1) Sustained exertion in heat by unacclimatized workers. 2) Lack of physical fitness and obesity. 3) Recent alcohol intake. 4) Dehydration. 5) Individual susceptibility. 6) Chronic cardiovascular disease in the elderly.	Heat Stroke: Failure of the central drive for sweating (cause unknown) leading to loss of evaporative cooling and an uncontrolled accelerating rise in core temperature. Heat Hyperpyrexia: Partial rather than complete failure of sweating.	Heat Stroke: Immediate and rapid cooling by immersion in chilled water with massage or by wrapping in wet sheet with vigorous fanning with cool dry air. Avoid overcooling. Treat shock if present. Heat Hyperpyrexia: Less drastic cooling required if sweating still present and core temperature <105°F.	Medical screening of workers. Selection based on health and physical fitness. Acclimatization for 8-14 days by graded work and heat exposure. Monitoring workers during sustained work in severe heat. Consume liquids and take rest breaks.
2.	Heat Cramps	Painful spasms of muscles used during work (arms, legs, or abdominal). Onset during or after work hours.	1) Heavy sweating during hot work. 2) Drinking large volumes of water without replacing salt loss.	Loss of body salt in sweat. Water intake dilutes electrolytes. Water enters muscles, causing spasm.	Salted liquids by mouth, or more prompt relief by I-V infusion	Adequate salt and potassium intake with meals.
3.	Heat Syncope	Fainting while standing erect and immobile in heat.	Lack of acclimatization.	Pooling of blood in dilated vessels of skin and lower parts of body.	Remove to cooler area. Recovery prompt and complete.	Acclimatization. Intermittent activity to assist venous return to heart.
4.	Heat Exhaustion	1) Fatigue, nausea, headache, giddiness. 2) Skin clammy and moist. Complexion pale, muddy or hectic flush. 3) May faint on standing with rapid thready pulse and low blood pressure. 4) Oral temperature normal or low but rectal temperature usually elevated (99.5 -101°F). Water restriction type: Urine volume small, high concentrated. Salt restriction type: Urine less concentrated chlorides less than 3 g/l.	1) Sustained exertion in heat. 2) Lack of acclimatization. 3) Failure to replace water and/or salt lost in sweat.	1) Dehydration from deficiency of water and/or salt intake. 2) Depletion of circulating blood volume. 3) Circulatory strain from competing demands for blood flow to skin and to active muscles.	Remove to cooler area. Recovery prompt and complete.	Acclimatization. Intermittent activity to assist venous return to heart.

Type of Heat Stress	Symptoms of Exposure	Predisposing Factors	Underlying Physiological Disturbance	Treatment	Prevention
5. Skin Eruptions					
a) Heat Rash ("prickly heat")	Profuse tiny raised red vesicles (blister-like) on affected areas. Pricking sensations during heat exposure.	Unrelieved exposure to humid heat with skin continuously wet with unevaporated sweat.	Plugging of sweat gland ducts with retention of sweat and inflammatory reaction.	Mild drying lotions. Skin cleanliness to prevent infection.	Cooled sleeping quarters to allow skin to dry between heat exposures.
b) Anhidrotic Heat Exhaustion	Extensive areas of skin which do not sweat on heat exposure, but present goose flesh appearance, which subsides with cool environments. Associated with incapacitation in heat.	Weeks or months of constant exposure to climatic heat with previous history of extensive heat rash and sunburn. Rarely seen except in troops in wartime.	Skin trauma (heat rash; sunburn) causes sweat retention deep in skin. Reduced evaporative cooling causes heat intolerance.	No effect treatment available for anhidrotic areas of skin. Recovery of sweating occurs gradually on return to cooler climate.	Treat heat rash and avoid further skin trauma by sunburn. Periodic relief from sustained heat.

ATTACHMENT 6

ACCIDENT/INCIDENT INVESTIGATION REPORT

ENSR

SUPERVISOR'S ACCIDENT/INCIDENT INVESTIGATION REPORT

Injured Employee ____________________ Title ____________________

Date of accident/incident ____________________ Time __________ Dept. __________

Location ____________________ Time on this job ____________________

Engaged in what work when injured? ____________________

____

Nature accident/incident? ____________________

____

____

How did accident/incident occur? ____________________

____

____

____

____

____

____

What can be done to prevent reoccurrence of the accident? ____________________

____

____

What has been done to prevent reoccurrence of the accident? ____________________

____

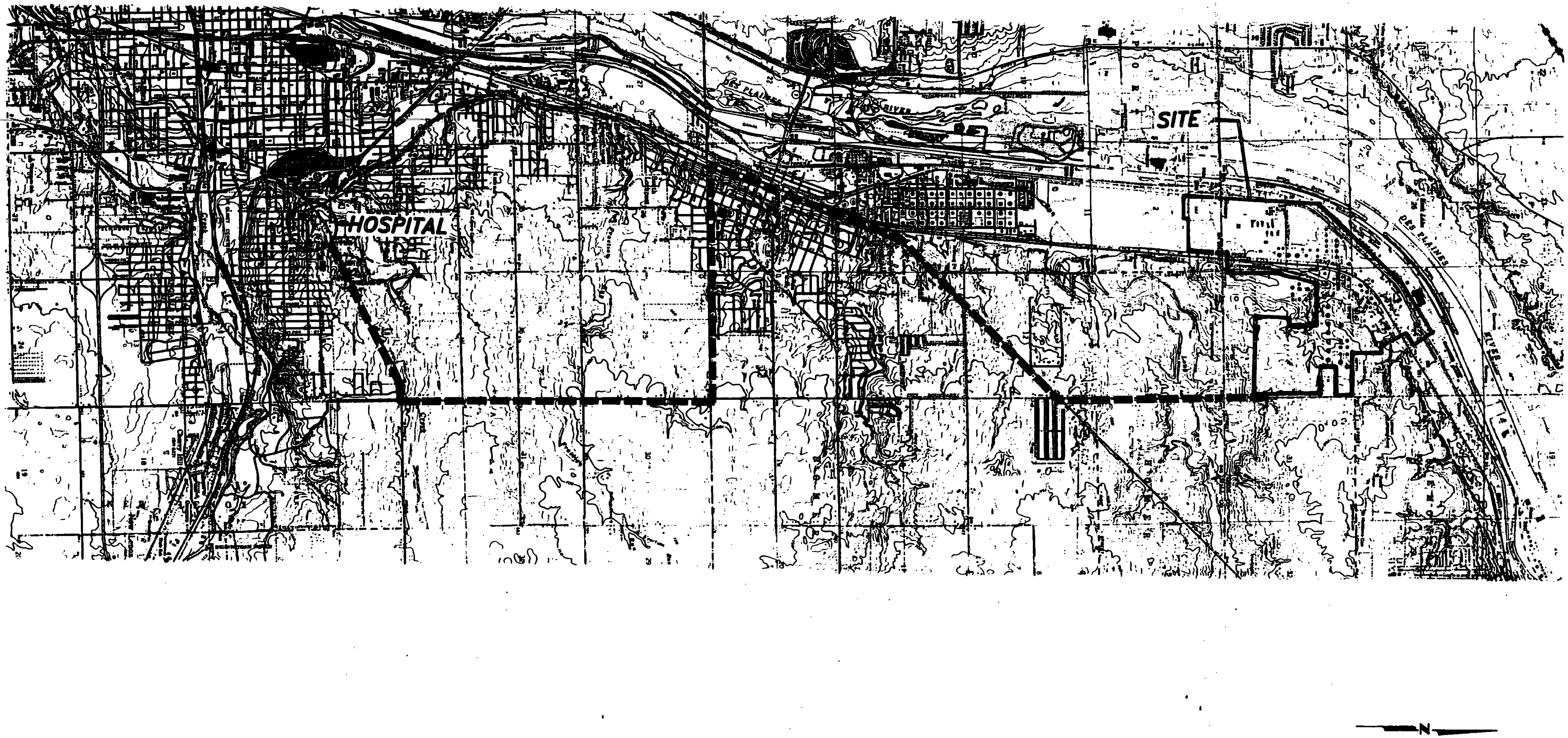
____

Supervisor's Signature ____________________ Dept. __________ Date __________

Reviewer's Signature ____________________ Dept. __________ Date __________

ATTACHMENT 7

HOSPITAL ROUTE MAP



ENSR CONSULTING AND ENGINEERING

HOSPITAL ROUTE MAP
UNO-VEN REFINERY
LEMONT, ILLINOIS

PROJECT NUMBER: 6941-009-100

APPENDIX C

ENSR'S STANDARD OPERATING PROCEDURES

ENSR

STANDARD OPERATING PROCEDURE

Number: 1005 Date of Issue: 2nd Qtr. 1989

Title: Numerical Analysis and Peer Review

Organizational Acceptance	Authorization	Date
Originator	Scott M. Whittemore	10-31-85
Department Manager	[illegible]	[illegible]
Divisional Manager	Peter Shanahan	Oct 31 1985
Group Quality Assurance Officer	Scott M. Whittemore	10-31-85
Other		

Revisions	Changes	Authorization	Date
1	Title : • Changed Number from 2005 to 1005	Scott M. Whittemore	5-9-89

Title: Numerical Analysis and Peer Review

1. Purpose and Applicability

This document describes ENSR's procedure for ensuring that all data analyses for site investigations and other studies are correct and consistent with project objectives and are legibly and retrievably documented. The purpose of the documentation is to permit peer review and reconstruction of the logic by which any conclusions were deduced.

2. Responsibilities

The responsibility for implementation of this procedure on each project rests with the person performing the calculations.

The project manager is responsible for ensuring the completeness of project files.

3. Method of Documentation

3.1 Manual Calculations

3.1.1 All calculations shall be documented in legible, reproduction-quality records. The records shall be complete enough to permit logical reconstruction by a qualified person other than the originator.

3.1.2 Calculations should be maintained in division files during the project, and shall be placed into the central project file at the end of the project.

3.1.3 Each calculation should be assigned a unique identification number by an appropriate person. The calculations may be consecutively numbered within a given project. (e.g., D010-1, D010-2,...).

3.1.4 Calculations for each project should be kept in a binder with an index sheet.

3.1.5 Records of calculations shall contain, on each page, the initials of the originator and reviewer, the date, the project number, calculation number and page number.

3.1.6 Each calculation shall have a cover page which should contain:

- o client name,
- o project name and number,
- o calculation name and number,
- o total number of pages in the calculation,
- o date,
- o originator's signature.

3.1.7 The complete record of any series of calculations for a project shall have a cover page containing at least the following:

- o Statement of purpose
- o Brief description of method
- o Assumptions and justifications
- o Reference to input data sources
- o All numerical calculations, showing all units
- o Results
- o Reference to associated computer output
- o Signature of originator and date

3.2 Computer Programs

Documentation and qualification procedures for ENSR-written computer programs are detailed in ENSR SOP 1006. Each revision of each program is documented in an annotated hard copy of the software. Annotations should be sufficient to permit a qualified individual other than the originator to understand how the program works. Minimum contents of such a record are:

- o Program name
- o Originator's name
- o Input parameters
- o Date of printout
- o Revision number
- o Each page should be numbered, and should indicate the total number of pages in the record

These records are archived along with the qualification records in a central file.

3.3 Computer Program Output

3.3.1 All final computer program output used in a given project will be retained in hard copy in the project files. The output should be bound and assigned a unique reference number.

3.3.2 Each program output record shall contain at least the following:

- o Name and revision date of program or model used
- o Input parameters
- o Name of user
- o Date of run

3.4 Drawings

3.4.1 All drawings shall be labeled with a unique identification number, which might consist of the project number and a sequential drawing number (e.g. D010-1, D010-2,...).

3.4.2 All drawings shall be constructed using standardized symbols and nationally-recognized drafting standards

3.4.3 All drawings shall be signed and dated by the originator and checked, signed and dated by a reviewer.

3.4.4 All drawings to be published must be approved for issue by the project manager or his designee.

4. Method for Review and Revision

4.1 All calculations and drawings for each project shall be verified by a qualified person other than the originator.

4.2 Verification shall consist of a thorough check of the calculations for the following elements:

- **o Appropriateness of method,**
- **o Appropriateness of assumptions,**
- **o Correctness of calculations,**
- **o Completeness of references,**
- **o Completeness of record.**
- **o Correctness of input parameters for calculations using computer programs.**

4.3 Method of Review - It is the responsibility of the reviewer to assure that the methodology used and results obtained are correct. This may require verification of each number in the calculation, but this is usually not necessary. Typically, spot checks of the computations and visual inspection for the reasonableness constitute a sufficiently thorough check.

In some cases, it may be appropriate and economically feasible for the reviewer to perform a complete, independent calculation using a different, but appropriate method.

It is up to the reviewer to determine the appropriate method of review.

4.4 If the reviewer recommends revisions, the reviewer and originator will confer until any disagreements are resolved.

4.5 After determining that the calculation is acceptable, the reviewer will sign and date the cover page and initial and date the remaining pages.

4.6 A photocopy of the approved calculation record is made and filed in the central project file.

ENSR

STANDARD OPERATING PROCEDURE

Number: 7130 **Date of Issue:** 2nd Qtr.1993

Revision: 2

Title: Ground-Water Sample Collection from Monitoring Wells

Organizational Acceptance	**Authorization**	**Date**
Originator	Christopher Carlio	3/13/84
Technical Reviewer	Arthur Lazarus	3/13/84
Technical Reviewer	Elaine Moore	3/13/84
Technical Reviewer		
Quality Assurance	Scott Whittemore	3/13/84

Revision #	Changes	Authorization	Date
1	• Addition of Equipment Checklists	Scott Whittemore Charles Martin Elaine Moore	9/5/86 9/11/86 9/10/86
	• The use of electronic sounding devices for water-level measurements has been removed		
	• Unnecessary steps have been deleted from decontamination procedures		
	• Volume requirements for ground-water purging has been changed from 4 - 10 to 3 - 10 volumes		
	• Additional bailing details added		
	• Additonal figures were added		
	• Miscellaneous rewording		
2	• Ground-Water Sample Collection Record, Chain-of-Custody and Sample Label form updates	Mike Dobrowolski	4/27/93
	• Format update		

Organizational acceptance signatures are maintained on file with the original document in the Quality Assurance Library in Acton, MA.

SOP NO: 7130

ENSR ENSR Consulting and Engineering

Ground-Water Sample Collection from Monitoring Wells

Date:	2nd Qtr. 1993
Revision No:	2
Author:	Christopher Carlio
Discipline:	Geosciences

1.0 PURPOSE AND APPLICABILITY

This standard operating procedures (SOP) is concerned with the collection of valid and representative samples from ground-water monitoring wells. The scope of this document is limited to field operations and protocols applicable during ground-water sample collection.

2.0 RESPONSIBILITIES

The site coordinator or designee will have the responsibility to oversee and ensure that all ground-water sampling is performed in accordance with the project-specific sampling program and this SOP. In addition, the site coordinator must ensure that all field workers are fully apprised of this SOP. The field team is responsible for proper sample handling as specified in SOP 7510, Packaging and Shipment of Samples.

3.0 REQUIRED MATERIALS

The list below identifies the types of equipment which may be used for a range of ground water-sampling applications. From this list, a project-specific equipment list will be selected based upon project objectives, the depth to ground-water, purge volumes, analytical parameters and well construction. The types of sampling equipment are as follows:

- Purging/Sample Collection

  Bailers
  Centrifugal Pump
  Submersible Pump
  Peristaltic Pump

- Sample Preparation/Field Measurement

  pH Meter
  Specific Conductance Meter
  Filtration Apparatus

Water-Level Measurement Equipment

Additional equipment to support sample collection and provide baseline worker safety will be required to some extent for each sampling task. The additional material are separated into two primary groups: general equipment which is reusable for several samplings, and materials which are expendable.

- General

  Project-specific Sampling Plan
  Deionized-water dispenser bottle
  Decontamination Solvent-dispenser bottle
  Site-specific Health & Safety equipment (gloves, respirators, goggles)
  Field data sheets and/or log book
  Preservation solutions
  Sample containers
  Buckets and intermediate containers
  Coolers
  First-Aid kits

- Expendable Materials

  Bailer Cord
  Respirator Cartridges
  Gloves
  Water Filters
  Chemical-free paper towels
  Plastic sheets

Equipment checklists have been developed to aid in field trip organization and should be used in preparation for each trip.

- ENSR SOP 7131, Field Filtration of Water Samples for Inorganics
- ENSR SOP 7510, Packaging and Shipment of Samples
- ENSR SOP 7600, Decontamination of Equipment

4.0 METHOD

4.1 Water-Level Measurement

4.1.1 Prior to obtaining a water-level measurement, cut a slit in one side of a plastic sheet and slip it over and around the well, creating a clean surface onto which the sampling equipment can be positioned. This clean working area should be a minimum of eight feet square. Care will be taken not to kick, transfer, drop, or in any way let soil or other materials fall onto this sheet unless it comes from inside the well. Do not place meters, tools, equipment, etc. on the sheet unless they have been decontaminated.

4.1.2 Unlock and/or open the monitoring well. Enter a description of condition of the security system and protective casing on the Ground-Water Sample Collection Record shown in Figure 1.

4.1.3 Check for the measuring point for the well. The measuring point location should be clearly marked on the outermost casing or identified in previous sample collection records. If no measuring point can be determined, a measuring point should be established. Typically, the top (highest point) of the protective or outermost well casing will be used as the measuring point. The measuring point location should be described on the Ground-Water Sample Collection Record and should be the same point used for all subsequent sampling efforts.

4.1.4 To obtain a water-level measurement lower a decontaminated steel or fiberglass tape into the monitoring well. Care must be taken to assure that the water-level measurement device hangs freely in the monitoring well and is not adhering to the wall of the well casing. The water-level measuring tape will be lowered into the well until the audible sound of the unit is detected or the light on an electronic sounder illuminates. At this time the precise measurement should be determined (to hundredth of a foot) by repeatedly raising and lowering the tape to converge on the exact measurement. The water-level measurement as well as the point of measurement should be entered on the Ground-Water Sample Collection Record.

4.1.5 Decontamination

The measurement device shall be decontaminated prior to and immediately after use in accordance with ENSR SOP 7600, *Decontamination of Equipment*. Generally, only that portion of the tape which enters the water table should be cleaned. It is important that the measuring tape is never placed directly on the ground surface.

4.2 Purge-Volume Computation

All monitoring wells to be purged prior to sample collection. Depending upon the ease of purging, 3 to 10 volumes of ground water present in a well shall be withdrawn prior to sample collection or one volume if the well can be purged dry. The volume of water present in each well shall be computed based on the length of water column and well casing diameter. The water volume shall be computed using the volume factors or graph presented in Figure 2.

4.3 Well Purging

Purging must be performed for all ground-water monitoring wells prior to sample collection in order to remove stagnant water from within the well casing and ensure that a representative sample is obtained. The following sections explain the proper procedures for purging and collecting water samples from monitoring wells.

Three general types of equipment are used for well purging: bailers, surface pumps, or down-well submersible pumps.

In all cases pH and/or specific conductance will be monitored during purging. Field parameter values will be entered on the Ground-Water Sample Collection Record along with the corresponding purge volume.

4.3.1 Bailing

In many cases bailing is the most convenient method for well purging. Bailers are constructed using a variety of material; generally, PVC stainless steel, and Teflon®. Care must be taken to select a specific type of bailer that suits a study's particular needs. Teflon® bailers are generally most "inert" and are used most frequently. Keep in mind the diameter of each monitoring well so that the correct size bailers are taken to the site. It is preferable to use one bailer per well; however, field decontamination is a relatively simple task if required.

Bailing presents two potential problems with well purging. First, increased suspended solids may be present in samples as a result of the turbulence caused by raising and lowering the bailer through the water column. High solids concentrations may require that total suspended solids (TDS) and the chemical character of solids be evaluated during sample analyses. Second, bailing may not be feasible for wells which require that greater than twenty (20) gallons be removed during purging. Such bailing conditions mandate that long periods be spent during purging and sample collection or that centrifugal pumps be used. All ground-water collected from monitoring wells for subsequent volatile organic compounds analyses shall be collected using bailers, regardless of the purge method.

4.3.2 Surface Pumping

Ground-water withdrawal using pumps located at the ground surface is commonly performed with centrifugal or peristaltic pumps.

All applications of surface pumping will be governed by the depth to the ground-water surface. Peristaltic and centrifugal pumps are limited to conditions where ground water need only be raised through approximately 20 feet of vertical distance. The lift potential of a surface pumping system will depend upon the net positive suction head of the pump and the friction losses associated with the particular suction line, as well as the relative percentage of suspended particulates.

Surface pumping can be used for many applications of well purging and ground-water sample collection. In all cases, pumping cannot be used for the collection of samples to be analyzed for volatile organic compounds (VOCs).

- Peristaltic Pump

  Peristaltic pumps provide a low rate of flow typically in the range of 0.02-0.2 gallons/min (75-750 ml/min). For this reason, peristaltic pumps are not particularly effective for well purging. Peristaltic pumps are suitable for purging situations where disturbance of the water column must be kept minimal for particularly sensitive analyses. Peristaltic pumps are most often used in conjunction with field filtering of samples and therefore can be used to obtain water samples for direct filtration at the wellhead.

- Centrifugal Pump

  Centrifugal pumps are designed to provide a high rate of pumping, in the range of 10-40 gallons per minute (gpm), depending on pump capacity. Discharge rates can also be regulated somewhat provided the pump has an adjustable throttle.

  When centrifugal pumps are used, samples should be obtained from the suction (influent) line during pumping by an entrapment scheme (Figure 3). Construction of this sampling scheme is relatively simple and will not be explained as part of this SOP. It is suggested that if samples cannot be obtained before going through the pump, that samples be obtained by using a bailer once pumping has ceased. Collecting samples from the pump discharge is not recommended.

4.3.3 Submersible Pump

Submersible pumps provide an effective means for well purging and in some cases sample collection. Submersible pumps are particularly useful for situations where the depth to water table is greater than twenty (20-30) feet and the depth or diameter of the well requires that a large purge volume be removed during purging.

ENSR uses the Johnson-Keck pump model SP-81 which has a 1.75 inch diameter pump unit. The pump diameter restricts use to monitoring wells which have inside diameters equal to or greater than two (2) inches. As with other pump-type purge/sample collection methods, submersible pumps will not be used for the collection of samples for analyses of volatile organic compounds. Submersible pumps should never be used for well development as this will seriously damage the pump.

4.4 Sample Collection Procedures

4.4.1 Bailing

Obtain a clean/decontaminated bailer and a spool of polypropylene rope or equivalent bailer cord. Using the cord at the end of the spool, tie a bowline knot or equivalent through the bailer loop. Test the knot for security and the bailer itself to ensure that all parts are intact prior to inserting the bailer into the well.

Remove the protective foil wrapping from the bailer, and lower the bailer to the bottom of the monitoring well and cut the cord at a proper length. Boiler rope should never touch the ground surface at any time during the purge routine.

Raise the bailer by grasping a section of cord using each hand alternately in a "rocking" action. This method requires that the samplers' hands be kept approximately 2-3 feet apart and that the bailer rope is alternately looped onto or off each hand as the bailer is raised and lowered.

Bailed ground water is poured from the bailer into a graduated bucket to measure the purged water volume.

For slowly recharging wells, the bailer is generally lowered to the bottom of the monitoring well and withdrawn slowly through the entire water column. Rapidly recharging wells should be purged by varying the level of bailer insertion to ensure that all stagnant water is removed. The water column should be allowed to recover to 70-90% of its static volume prior to collecting a sample. Water samples should be obtained from midpoint or lower within the water column.

Samples collected by bailing will be poured directly into sample containers from bailers which are full of fresh ground water. During sample collection, bailers will not be allowed to contact the sample containers.

4.4.2 Peristaltic Pump

Place a new suction and discharge line to the peristaltic pump. Silicon tubing must be used through the pump head. A second type of tubing may be attached to the silicon tubing to create the suction and discharge lines. Such connection is advantageous for the purpose of reducing tubing costs, but can only be done if airtight connections can be made. Tygon tubing will not be used when performing well purging or collecting samples for organic analysis. The suction line must be long enough to extend to the static ground-water surface and reach further should drawdown occur during pumping.

Measure the length of the suction line and lower it down the monitoring well until the end is in the upper 2-5 inches of the water column present in the well. Start the pump and direct the discharge into a graduated bucket.

Measure the pumping rate in gallons per minute by recording the time required to fill a selected volume of a bucket. Flow measurement shall be performed three times to obtain an average rate.

The pumping shall be monitored to assure continuous discharge. If drawdown causes the discharge to stop, the suction line will be lowered very slowly further down into the well until pumping restarts.

Measurements of pH and specific conductance will be made periodically during well purging. All readings will be entered on the Ground-Water Sample Collection Record.

Samples will be collected after the required purge volume has been withdrawn and the field parameters (pH and specific conductance) have stabilized.

When the sample bottles are prepared, each shall be filled directly from the discharge line of the peristaltic pump. Care will be taken to keep the pump discharge line from contacting the sample bottles. Ground-water samples requiring filtration prior to placement in sample containers, will be placed in intermediate containers for subsequent filtration or filtered directly using the peristaltic pump.

At each monitoring point when use of the peristaltic pump is complete, all tubing including the suction line, pump head and discharge line must be disposed of. In some cases where sampling will be performed frequently at the same point, the peristaltic pump tubing may be retained between each use in a clean zip-lock plastic bag.

4.4.3 Centrifugal Pump

- Direct Connection Method (Note: This method requires that the well casing be threaded at the top.)

  Establish direct connection to the top of the monitoring well if possible using pipe connections, extensions, and elbows, with Teflon® tape wrapping on all threaded connections. If the centrifugal pump will subsequently be used for sample collection, a sample isolation chamber will be placed in the suction line configuration as shown in Figure 3.

  Prime the pump by adding tap water to the pump housing until the housing begins to overflow.

  Start the pump and direct the discharge into a graduated bucket or a bucket of known capacity (>2.5 gallons).

  Start the pump and measure the pumping rate in gallons per minute by recording the time required to fill the graduated bucket. Flow measurement should be checked periodically to determine if pumping rates are continuous, fluctuating, or diminishing. If discharge stops, the pump will be throttled back to determine if pumping will restart at a lower rate. If pumping does not restart, the pump should be shut off to allow the well to recharge.

Measurements of pH and specific conductance will be made periodically during well purging. All readings will be entered on the Ground-Water Sample Collection Record. Samples will be collected after the required purge volume has been withdrawn and the field parameters (pH and specific conductance) have stabilized. Samples should be collected from an in-line discharge valve or with a bailer. The pump should be properly decontaminated between wells.

- Down-Well Suction-Line Method

  Lower a new suction line into the well. The suction line will have a total length great enough to extend to the water table and account for a minimum of five (5) feet of drawdown. Note should be made that drawdown may exceed the depth where pumping will terminate as a result of a limitation derived from suction-line conditions and the lift potential of the pump. All connections should be made using Teflon® ferrules and Teflon® thread wrapping tape. Run the pump as per Section 4.4.3.

  At each monitoring well when use of a centrifugal pump is complete, all suction line tubing should be disposed of properly.

4.4.4 Submersible Pump

Prior to using a submersible pump, a check will be made of well diameter and alignment. A 1.75 inch diameter decontaminated cylindrical tube should be lowered to the bottom of each monitoring well to determine if the alignment or plumbness of a well is adequate to accommodate the submersible pump. All observations will be entered in the Ground-Water Sample Collection Record.

Slowly lower the submersible pump into the monitoring well taking notice of any roughness or restrictions within the riser.

Count the graduations on the pump discharge line and stop lowering when the stainless steel portion is below the uppermost section of the static water column within monitoring well. Secure the discharge line and power cord to the well casing.

Connect the power cord to the power source (i.e., rechargeable battery pack or auto battery) and turn the pump on (forward mode). When running, the pump can usually be heard by listening near the well head.

Voltage and amperage meter readings on the pump discharge must be checked continuously. The voltage reading will decline slowly during the course of a field day representing the use of power from the battery. Amperage readings will vary depending upon the depth to water table. Amperage readings greater than 10 amps usually indicate a high solids content in the ground water which may cause pump clogging and serious damage. If a steady increase in amperage is observed, the pump should be shut off, allowed to stop, switched to the reverse mode, stopped again and then placed in forward mode. If high amperage readings persist, the pump should be withdrawn and checked using the large upright cylinder and tap water. Ground-water conditions such as high solids may require that an alternate purge/sample method be used.

Drawdown must also be monitored continuously by remaining near the well at all times and listening to the pump. When drawdown occurs, a metallic rotary sound will be heard as the pump intake becomes exposed and ceases to discharge water, but continues to run. The pump should be lowered immediately to continue pumping water within the uppermost section of the static water column.

NOTE: The submersible pump cannot be allowed to run while not pumping water for more than five seconds or the pump motor will burn out.

If drawdown continues to the extent that the well is pumped dry, the pump should be shut off and the well allowed to recharge. This on/off cycle may need to be repeated several times in order to purge the well properly.

Measurements of the pumping rate, pH, and specific conductance should be made periodically during well purging.

All readings and respective purge volumes should be entered on the Ground-Water Sample Collection Record.

While pumping is on-going and when sample bottles are prepared, bottles will be filled directly from the discharge line of the pump taking care not to touch sample bottles to the discharge line.

At each monitoring well when use of the submersible pump is complete, the pump, discharge line and power cord shall be decontaminated according to the procedures contained ENSR SOP 7600 Decontamination of Equipment.

4.5 Sample Preparation

4.5.1 Prior to sample collection or shipment, ground-water samples may require filtration and/or preservation dependent on the specific type of analysis required.

4.5.2 Specific preservation techniques are described in the EPA document, Handbook for Sampling and Sample Preservation of Water and Wastewater (EPA-600/4-82-029). The EPA manual and laboratory manager should be consulted during the planning stage of the project. Project-specific sampling plans shall be assembled using the approved procedures obtained from the EPA manual.

4.5.3 Filtration

Ground-water samples collected for dissolved metals analyses will be filtered prior to being placed in sample containers in accordance with ENSR SOP 7131, Field Filtration of Water Samples for Inorganics.

Ground-water filtration will be performed using a peristaltic pump and a 0.45 micron, water filter. Typically the water filters are 142 mm in diameter and are usually placed in 142 mm polycarbonate housings.

The filtration of ground-water samples shall be performed either directly from the monitoring well or from intermediate sample containers such as decontaminated buckets. In either case, well purging shall be performed first. Fresh ground water shall then be filtered and discharged from the filtration apparatus directly into sample containers.

For most dissolved metal analyses, pH adjustment of the sample is also required and shall be performed after filling the sample bottles. This is generally accomplished using laboratory supplied compounds such as sulfuric or nitric acid and sodium hydroxide. The preservative shall be identified in the Quality Assurance or Sampling Plan.

5.0 QUALITY CONTROL

Quality control requirements depend on project-specific circumstances and objectives and should be addressed in the Quality Assurance Project Plan (QAPP).

6.0 DOCUMENTATION

A number of different documents must be completed and maintained as a part of ground-water sampling effort. The documents provide a summary of the sample-collection procedures and conditions, shipment method, the analyses requested and the custody history. The list of documents is:

- Ground-water sample collection record
- Sample labels
- Chain of custody forms and tape
- Shipping receipts

Sample labels shall be completed at the time each sample is collected and will include the information listed below. A sample label is shown in Figure 4.

- Client or project name
- Sample number
- Designation (i.e., identification of sample point no.)
- Analysis

- Preservative (e.g., filtration, acidified pH<2 HNO_3)
- Sample-collection date
- Sampler's name

Figure 5 displays the chain of custody record used by ENSR. The chain of custody form is the record of sample collection and transfer of custody. Information such as the sample collection date and time of collection, sample identification and origination, client or project name shall be entered on each chain of custody record. In accordance with 40 CFR 261.4(d) the following information must accompany all ground water samples which are known to be non-hazardous and to which U.S. Department of Transportation and U.S. Post Office regulations do not apply. Such information is:

- sample collector's name, mailing address and telephone number,
- analytical laboratory's name, mailing address and telephone number,
- quantity of each sample,
- date of shipment, and
- description of sample.

The chain of custody forms provide a location for entry of the above-listed information.

7.0 REFERENCES

EPA, Handbook for Sampling and Sample Preservation of Water and Wastewater EPA-600/4-82-029, September 1982.

Geotrans, Inc. RCRA Permit Writer's Manual, Ground-Water Protection prepared for U.S. EPA. Contract No. 68-01-6464, October 1983.

Code of Federal Regulations, Chapter 40 (Section 261.4(d).

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WELL NO.

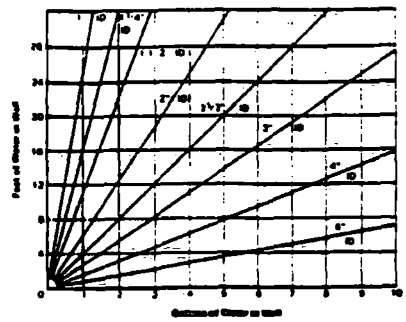
GROUND WATER SAMPLE COLLECTION RECORD

Project No. ______________________ Date ____________ Time: Start ____________ am/pm

Project Name ____ Finish ____________ am/pm

Location ____

Weather Conds.: ______________________ Collector ______________________



1. WATER LEVEL DATA: (measured from ToC)

a. Total Well Length ____________ Well Casing Type ____________

b. Water Table Depth ____________ Casing Diameter ____________

c. Length of Water Column ____________ (a-b)

d. Calculated Purgeable Volume ____________

2. WELL PURGEABLE DATA

a. Purge Method ____

b. Required Purge Volume (@ ________ well volumes) ____________________

c. Field Testing: Equipment Used ____________________________________

Volume Removed	T°	PH	Spec. Cond.	Color	Other

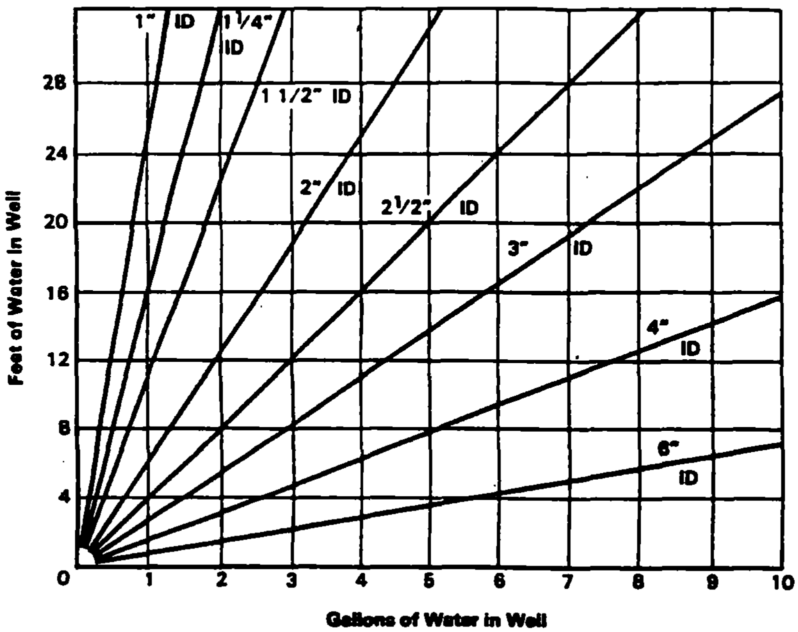
3. SAMPLE COLLECTION: Method ____________________________________

Container Type	Preservation	Analysis Req.

Comments ____

M850944

Figure 1



(a) Graphical Explanation

Volume/Linear Ft. of Pipe		
ID(in)	Gal	Liter
1/4	0.003	0.010
3/8	0.006	0.022
1/2	0.010	0.039
3/4	0.023	0.087
1	0.041	0.154
2	0.163	0.618
3	0.367	1.39
4	0.653	2.47
6	1.47	5.56

(b) Volume Factors

Figure 2 Purge Volume Computation

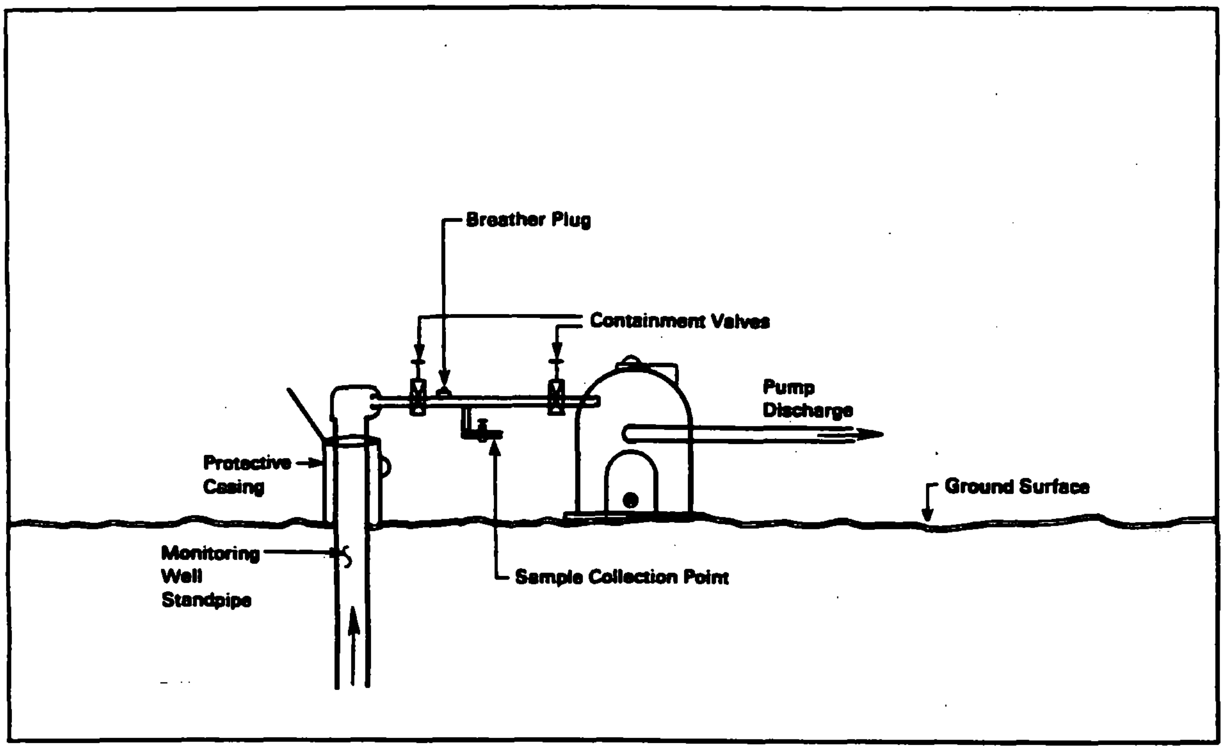


Figure 3   Down Well Suction Line Configuration

M910271

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ENSR Consulting and Engineering

SITE ______________ PROJECT# ____________

SAMPLE ID# ______________________________

ANALYSIS ________________________________

PRESERVATIVE: HNO_3, H_2SO_4, OTHER __________

DATE ______________ TIME ____________

SAMPLER _________________________________

OTHER ___________________________________

Figure 4 Sample Container Label

M910271

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ENSR Consulting and Engineering

SITE ________________ PROJECT# ____________

SAMPLE ID# ______________________________

ANALYSIS ________________________________

PRESERVATIVE: HNO_3, H_2SO_4, OTHER __________

DATE ________________ TIME ____________

SAMPLER ________________________________

OTHER __________________________________

Figure 4 Sample Container Label

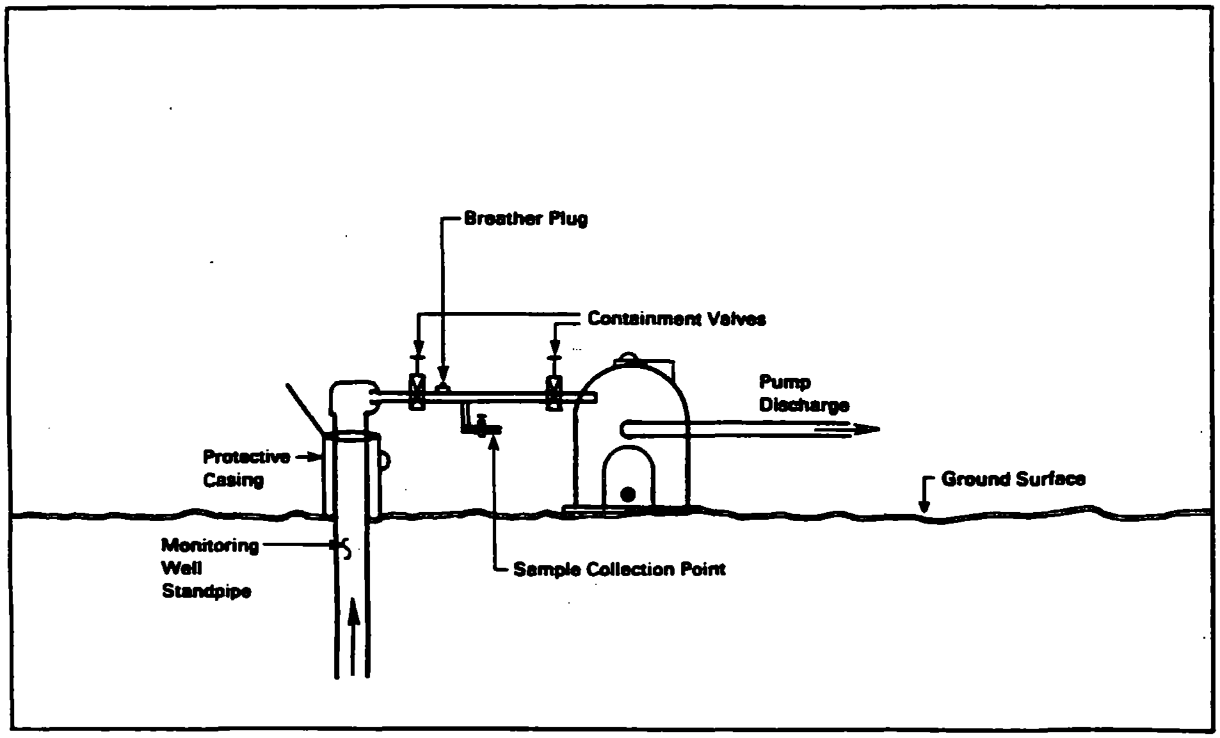

Figure 3 Down Well Suction Line Configuration

M901376

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CHAIN OF CUSTODY RECORD

Page ____ of ____

Client/Project Name:	Project Location:
Project Number:	Field Logbook No.:
Sampler: (Print Name) /Affiliation:	Chain of Custody Tape No.:
Signature:	Send Results/Report to:

Analysis Requested

Field Sample No./ Identification	Date	Time	Grab	Comp	Sample Container (Size/Mat'l)	Sample Type (Liquid, Sludge, Etc.)	Preservative	Field Filtered							Lab I.D.	Remarks

Relinquished by: (Print Name)	Date:	Received by: (Print Name)	Date:	Analytical Laboratory (Destination):
Signature:	Time:	Signature:	Time:	
Relinquished by: (Print Name)	Date:	Received by: (Print Name)	Date:	
Signature:	Time:	Signature:	Time:	
Relinquished by: (Print Name)	Date:	Received by: (Print Name)	Date:	
Signature:	Time:	Signature:	Time:	Serial No. 6118

Figure 5 Sample Chain-of-Custody Record

ENSR STANDARD OPERATING PROCEDURE

Number: 7210 Date of Issue: 1st Quarter, 1984

Title: Rock Coring

Organizational Acceptance	Authorization	Date
Originator	Charles S Martin	3/2/84
Department Manager	Arthur S Lyman	3/2/84
Divisional Manager	Elaine Moore	3-2-84
Group Quality Assurance Officer	[illegible]	3/2/84
Other		

Revisions	Changes	Authorization	Date
1	Update	SMW	3/2/84
		CEM	3/2/84
		AGL	3/2/84
		EM	3-2-84

STANDARD OPERATING PROCEDURE

Title: **Rock-Core Drilling**

Date: 1st Qtr 19
Number: 7
Revision: 1

1.0 Purpose and Applicability

This SOP describes the methods used for obtaining rock core samples for establishing the stratigraphy, structure, and geotechnical properties of the rock.

2.0 Responsibilities

It is the responsibility of the contract driller to provide the necessary equipment for coring and to collect the designated samples.

It is the responsibility of the project geologist/engineer to observe the coring operation and to log all cores that are collected using the approved forms.

3.0 Supporting Materials

All drill rigs used for rock coring shall be equipped with hydraulic feed. Driven or drilled-in flush joint casing shall be employed. For driven casing, it may not be necessary to record the casing blows. Drill rods for drilling rock should be NW in size to minimize vibration and chattering. Rock core size shall be NX or NQ (Wire Line) or as required by the Project Task Plan. Core barrels shall be of the improved double-tube varieties such as the Christensen Series C or D models or equivalent, and shall be equipped with a split inner tube. In general, 5-foot barrels will be employed at the discretion of the inspecting geologist.

Core boxes shall be provided by the contract driller for storage purposes.

4.0 Coring Procedures

4.1 General Information

4.1.1 Typically, soil sampling and rock coring will be performed in the same borehole. Casing shall be required for the full depth of the overburden in borings in which rock will be cored.

4.1.2 The inspecting geologist may allow the use of drilling mud to advance the boring for unusual combinations of soil and ground-water conditions. Prior to commencing rock drilling, however, casing shall be inserted in the mudded hole and firmly seated in rock. Biodegradable drilling fluids such as Johnson's Revert shall be used. Other fluids, such as bentonite slurry, is subject to the approval of the project geologist or his delegate.

4.2 Procedure

4.2.1 Casing shall be firmly seated into the bedrock surface prior to commencing rock drilling. The drilling methods employed shall adjusted continuously to obtain maximum core recovery of the rock being drilled. This will involve careful attention to the rates of feed and rotation and the rate of flow of drilling fluid. These rates shall be adjusted as necessary to maximize recovery. Types of bits shall also be carefully selected as to diamond size, matrix and the configuration of the bit face and water ports, so as to produce the maximum recovery for each type of rock. The inspecting geologist may require that the type of bits be varied in each hole as different rock types are encountered. In no case shall worn or damaged bits be used. Core lifters shall be checked and replaced as soon as excessive wear is evident.

4.2.2 The inspecting geologist shall make an independent determination of depth measurements and check his determinations with those made by the drilling foreman. Any discrepancy shall be resolved in the field as soon as it is discovered. All depth measurements shall be made in feet and tenths of feet.

4.2.3 Every effort should be made to use clear water as a drilling fluid. In the event that this is impractical, recirculated water may be used at the discretion of the inspecting geologist, providing a settling tank and filtering system is provided. If drilling mud is used to advance the boring through the overburden, the hole shall be washed free of all mud prior to the commencement of rock drilling.

4.2.4 To minimize core losses in soft, erodable rock, the following measures shall be required by the inspecting geologist:

- Drilling shall be restricted to short runs of 2 to 3 feet;

- Drilling water pressure shall be kept low (under 150 psi);

- Feed pressure shall be kept under 100 psi.

4.2.5 Split-spoon drive samples may be taken in any zones where it is not possible to drill and obtain satisfactory recovery of soft erodable rocks. Satisfactory recovery for this purpose is defined as 50% or greater.

4.2.6 The inspecting geologist shall not permit a full coring run to be drilled if he suspects core was left in the hole on the previous run. If this is believed to have occurred, he shall direct that the next coring run be shortened by the length of core believed to have been left in the hole. This is necessary to prevent blocking the core barrel and grinding of the core.

4.3 Sample Handling and Storage

4.3.1 Upon removal of the core barrel from the drill hole, the split inner tube shall be removed and opened and, if necessary to facilitate accurate logging, the core shall be washed while it rests in the liner half. Care shall be used in washing to avoid removing small pieces of core or soft joint or vein fillings. If the rock is soft, friable, or otherwise erodable and, in the opinion of the inspecting geologist, washing will damage the core, the washing process shall be omitted.

4.3.2 The core shall be placed in wooden boxes specially constructed to hold and store rock cores. The core shall be placed in the core box with the top of the run at the upper left corner and the remaining core placed sequentially from left to right and from the rear (nearest the cover hinge) of the box to the front.

4.3.3 Wooden blocks marked with the appropriate depth and run number shall be placed between each separate core run. In addition, wherever core is lost due to the presence of a cavity or large joint (open or filled), a spacer shall be placed in the proper relative position in the core box. The spacer shall be the same length as that of the lost core and the depth range shall be marked on the spacer along with the reason for the missing core (e.g., cavity, large joint, etc.)

4.3.4 The core box shall be marked on the top and two ends with the client's name, site identification, boring number, depth range, and box number. The RQD shall be indicated on all core boxes.

5.0 Documentation

5.1 The inspecting geologist shall prepare a field boring log of each boring. The boring log shall be kept current. In addition to the data entries noted, the inspecting geologist should be careful to observe and note any of the following:

- Information on any blocking or grinding of the core during the run;

- Changes in color or flow rate of the return water;

- Any unusual action of the drill rods, sudden chattering of the core barrel, rapid drop of the drill rods, etc.

Other information to include on the boring log shall be:

- Elevation of bottom of casing when seated on bedrock.
- Type of core drill, including size of core.
- Length of core recovered for each length drilled, with resulting percentage of recovery.
- Elevation at which rock was encountered.
- Elevation of each change in type of bedrock.
- Elevation of any depth of drilling at which drill water is lost in making borings.
- Time required to drill each foot.

5.2 The bedrock shall be described in accordance with the procedures outlined in the SOP 7211 (Logging of Rock Cores) and will include:

1. Type: Granite, slate, shale, limestone, gneiss, sandstone, etc.
2. Condition: Broken, fissured, laminated, jointed, massive, etc.
3. Hardness: Soft, hard, medium hard, very hard, etc.

5.3 The inspecting geologist shall identify the borehole by marking the identification number of the borehole on the casing.

5.4 All documentation shall remain in the project files for an indefinite period of time following completion of the project.

ROCK CORE SAMPLE LOG

PROJECT NO. ______________________ PROJECT NAME ______________________

DATE ______________________

SITE LOCATION/BORING NO. ______________________

MONITORING WELL INSTALLED (Y, N) ________ BORING LOG (Y, N) ________

TOTAL DEPTH ____________

LENGTH OF CORE ____________

RECOVERY % ____________

CORE BOX NO. ____________

EQUIPMENT USED ______________________

COLLECTOR'S NAME ______________________

TOTAL TIME ________ - ________ HRS.

ROCK DESCRIPTION: TYPE/NAME ______________________

COLOR ______________________

DENSITY/HARDNESS ______________________

STRUCTURAL/TEXTURAL FEATURES ______________________

____

____

COMMENTS ______________________

____

LAB DESIGNATION ______________________

FURTHER ANALYSIS (TYPE) ______________________

Project ____________ Site ____________ **BORING** ________ Sh 1 of ____

Date Started ____________ Completed ____________ Ground Elevation ____________

Total Depth ____________ Location ____________ Logged by ____________

Casing I.D. ____________ Contractor ____________

Remarks ____________

Elev. Feet	Depth Feet	Sample				Graphic Log	Sample Description	Equipment Installed
		Type & Number	Blows per 6 In.	Depth Range	Rec.			

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ENSR STANDARD OPERATING PROCEDURE

Number: 7211 Date of Issue: 1st Quarter, 1984

Title: Logging of Rock Cores

Organizational Acceptance	Authorization	Date
Originator	Charles S Martin	3/2/84
Department Manager	Arthur S Lazarus	3/2/84
Divisional Manager	Elaine Moore	3-2-84
Group Quality Assurance Officer	[illegible]	3/2/84
Other		

Revisions	Changes	Authorization	Date
1	Update	SMW	3/2/84
		CEM	3/2/84
		ASL	3/2/84
		EM	3-2-84

STANDARD OPERATING PROCEDURE

Title: Logging of Rock Cores

Date: 1st Qtr '84
Number: 721
Revision: 1

1.0 Purpose and Applicability

This SOP describes the procedures for the logging of rock core in order to provide a written description of the rock conditions encountered in individual test borings. The basic objective of describing rock cores is to provide a concise record of important geological and physical characteristics of the rock core such as: rock type/name, lithological/structural features, any physical conditions, including alteration, and any special geological, mineralogical, or other features pertinent to interpretation of the subsurface conditions.

2.0 Responsibilities

It shall be the responsibility of the project geologist/engineer to maintain accurate records of all core samples that are collected and also any coring attempts which fail to retrieve a sample.

3.0 Supporting Materials

- Boring logs
- Hand lens for close inspection
- Marker for labelling
- Core boxes (usually provided by drilling subcontractor)
- Dilute hydrochloric acid
- Rock hammer and pen knife
- Six-foot folding rule

4.0 Logging Procedures

4.1 General Information

The following features shall be noted for all rock types:

- color, grain size, grain shape, and the mineralogy of the grains;
- attitude of bedding, cleavage or foliation planes, and the ease of splitting along such planes;
- the attitude and degree of jointing, whether open or filled, as well as evidence of shearing, crushing, or faulting;

- the degree of alteration or weathering, hardness of the rock, and other engineering properties;

- the "RQD" (Rock Quality Designation) for NX or larger size cores.

4.2 Igneous and Metamorphic Rocks

4.2.1 A typical description of an igneous or metamorphic rock shall include:

- name or generalized group name;

- color;

- identification of the major minerals and an estimation of the amount of each mineral (percentage estimates may be used);

- textural information and textural variations including mineral orientations, grain shapes, intergrowths, description of phenocrysts, and grain-size information;

- larger structural features such as jointing, flow banding, dip of beds, contact relationships, nature of metamorphism, and any hydrothermal effects;

- any weathering or mechanical characteristics.

4.2.2 In the field, igneous rocks should be classified according to texture and mineralogy/color to arrive at a generalized group name (for example, granite, anorthosite or basalt). Field descriptions of cataclastic rocks shall include information on the nature of the cataclasis, the type of original rock, size of blocks or clasts, presence of gouge, mineralization, and the width of zone(s).

4.2.3 If a detailed petrographic examination is performed, a more detailed classification system shall be utilized.

- Igneous rocks shall be classified according to nomenclature recommended by the IUGS Subcommission on the Systematics of Igneous Rocks (1973).

- Metamorphic rocks, with the exception of cataclastic rocks, shall be classified according to the manner outlined in Travis (1955). A mineral name should prefix a structural term (e.g., garnet-mica schist or muscovite-biotite-quartz gneiss; the prefix "meta" may be used for rocks that retain their original fabric e.g., metagabbro).

- Cataclastic rocks should be classified according to Higgins (1971).

4.3 Sedimentary Rocks

4.3.1 A typical description of a sedimentary rock shall include:

- name;
- color;
- texture of the rock, including any information on grain size(s) and identification and estimates of amounts of minerals and fossils;
- information on lithification and diagenesis, sedimentary structures, and stratigraphic relationships;
- the nature of the cementing material occupying the intergranular spaces;
- any sedimentary structures including a description of the bedding, and any features which are useful in determining geopetal relationships;
- a description of the weathering and engineering properties.

4.3.2 Classification of sedimentary rocks, both in core and in the field, should be based upon grain size (Wentworth, 1922), color or mineralogy and hardness;

4.3.3 If detailed petrographic examination is performed, one of the more deailed classification systems should be used. The system by Folk (1974) is suggested.

5.0 Special Tests/Analyses

5.1 Numerous analytical techniques are available to assist the core logger in his examination of the rock core. These include:

- thin section analysis;
- chemical analysis;
- radiometric age determinations;
- other special tests.

5.2 Samples to be tested or analyzed shall be selected and transmitted in accordance with required procedures.

6.0 Documentation

6.1 All descriptive data shall be noted on the final/geologic boring by the supervising geologist(s) for core logging.

6.2 All final boring logs shall be reviewed by the site or regional geologist to assure completeness and technical accuracy.

6.2.1 Any changes, additions, or deletions to the logs shall be made so that the original entry (words and/or numbers) is still legible. Under no circumstances will any erasures be allowed. If extensive deletions and additions are necessary, then a second boring log form may be attached to the original and labelled with the original sheet number and a small "a" after said number.

6.2.2 Upon completion of this review, the site or regional geologist shall initial and date the "Checked by" section of the boring log.

6.3 All documentation shall remain in the project files for an indefinite period of time following completion of the project.

Project ______ Site ______ BORING ______ Sh 1 of ____
Date Started ______ Completed ______ Ground Elevation ______
Total Depth ______ Location ______ Logged by ______
Casing I.D. ______ Contractor ______
Remarks ______

Elev. Feet	Depth Feet	Sample				Graphic Log	Sample Description	Equipment Installed
		Type & Number	Blows per 6 In.	Depth Range	Rec.			

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ROCK CORE SAMPLE LOG

PROJECT NO. ______________ PROJECT NAME ______________

DATE ______________

SITE LOCATION/BORING NO. ______________

MONITORING WELL INSTALLED (Y, N) ______ BORING LOG (Y, N) ______________

TOTAL DEPTH ______________

LENGTH OF CORE ______________

RECOVERY % ______________

CORE BOX NO. ______________

EQUIPMENT USED ______________

COLLECTOR'S NAME ______________

TOTAL TIME ________ - ________ HRS.

ROCK DESCRIPTION: TYPE/NAME ______________

COLOR ______________

DENSITY/HARDNESS ______________

STRUCTURAL/TEXTURAL FEATURES ______________

____

____

COMMENTS ______________

____

LAB DESIGNATION ______________

FURTHER ANALYSIS (TYPE) ______________

ENSR

STANDARD OPERATING PROCEDURES

Number: 7220

Date of Issue: 2nd Qtr. 1989

Title: Monitoring Well Construction and Installation

Organizational Acceptance	Authorization	Date
Originator	[illegible]	3-23-89
Technical Reviewer	[illegible]	4-10-89
Technical Reviewer	William M. Gregg	4-18-89
Technical Reviewer	MD [illegible]	5-2-89
Quality Assurance		

Revisions No.	Changes	Authorization	Date
2	Complete Rewrite	[illegible]	5-12-89

ENSR STANDARD OPERATING PROCEDURE

Number: 7220 Date of Issue: 1st Quarter, 1984

Title: Monitoring Well Construction

Organizational Acceptance	Authorization	Date
Originator	Charles E. Martin	3/2/84
Department Manager	Arthur S. [illegible]	3/2/84
Divisional Manager	[illegible] Moore	3-2-84
Group Quality Assurance Officer	[illegible]	3/2/84
Other		

Revisions	Changes	Authorization	Date
1	Update	SMW	3/2/84
		CEM	3/2/84
		AGL	3/2/84
		EM	3-2-84

1.0 Purpose and Applicability

This SOP establishes the method for installing ground water monitoring wells. These wells will be installed to monitor the depth to ground water, to measure aquifer properties, and to obtain samples of ground water for chemical analysis.

2.0 Definitions

Annulus: The space between the borehole wall and the outside of the well screen or riser pipe.

Filter Pack: A well-graded, clean sand or gravel placed around the well screen to prevent the entry of very fine soil particles.

Grout Plug: A cement/bentonite mixture use to seal a borehole that has been drilled to a depth greater than the final depth at which the monitoring well is to be installed.

Guard Pipe: A pipe, usually made of steel, placed around that portion of the well riser pipe that extends above the ground surface. As well as providing security to a well, it may provide a fixed elevation for surveying.

Riser Pipe: The section of unperforated well construction material used to connect the well screen with the ground surface. Frequently it is made of the same material and has the same diameter as the well screen.

Road Box: A man-hole set into the ground around a well installation. Usually constructed in areas where the monitoring well cannot extend above the ground surface for traffic or security reasons.

Tremie Pipe: A small diameter pipe that will fit in the annulus and is used to inject filter sands, seal materials, or cement/bentonite grout under pressure.

Well Screen: That portion of the well casing material that is perforated in some manner so as to provide a hydraulic connection to the aquifer. Typically a well screen has slots but holes, slits, louvers, and other perforations can, in some situations, be used.

3.0 Health and Safety Considerations

Monitoring well installation may involve chemical hazards associated with materials in the soil or aquifer being explored; and always involves physical hazards associated with the drill rig and well construction methods. When wells are to be installed in locations where the aquifer and/or overlying materials may contain chemical hazards, a Health and Safety Plan must be prepared and approved by the Health and Safety Officer before field work commences.

In addition, the following protective measures are required:

- all persons within 50 feet of the drill rig must wear hard hats and safety shoes. Hearing protection must be provided during periods of excessive noise; and

- personnel who are not directly involved in overseeing, inspecting or performing the drilling and well installation will remain at least 100 feet away from the drill rig.

4.0 Quality Assurance Planning Considerations

The following aspects of monitoring well design and installation procedures will depend on project-specific objectives and circumstances and should be addressed in the Quality Assurance Project Plan (QAPP).

- Construction materials for well screen, riser, filter pack and seals;

- Borehole drilling method;

- Depth and length of screen;

- Location and composition of seals; and

- Well head completion and protection.

Some states and EPA Regions have promulgated comprehensive guidelines for monitoring well configuration, and for subsurface investigation procedures. These will be followed as applicable, and the adaption of this SOP to accommodate those requirements will be explained in the QAPP.

5.0 Responsibilities

It is the responsibility of the Project Manager to ensure that each project involving monitoring well installation is properly planned and executed, and that the safety of personnel from chemical and physical hazards associated with drilling and well installation is protected.

Some states have specific requirements regarding the construction of monitoring wells. It is the responsibility of the Project Manager to understand these regulations and any permitting requirements that may be necessary, and to ensure that the well installation program complies with all state and local requirements.

It is the responsibility of the Project Geologist or Engineer to directly oversee the construction and installation of the monitoring well by the subcontract driller to ensure that the well-installation specifications defined in the project work plan are adhered to and that all pertinent data are recorded on the approved forms.

6.0 Training/Qualifications

Each person designing monitoring wells for ENSR projects and overseeing their installation should be a degreed geologist or hydrogeologist with at least two years experience in ground water monitoring. Specific training and/or orientation will be provided for each project to ensure that personnel understand the objectives and special circumstances and requirements of that project.

7.0 Supporting Materials

The monitoring well shall consist of a commercially available well screen constructed of PVC, stainless steel, teflon, or fiberglass pipe of minimum 2-inch nominal diameter. The length of the screen and the size of the screen slots shall be determined by the inspecting geologist or specified in the project work plan depending upon the grain-size distribution of the aquifer materials. PVC, stainless steel, steel, teflon, or fiberglass riser pipe of minimum 2-inch nominal diameter shall be used to complete the monitoring well to ground surface. The riser pipe shall be connected by flush-threaded, coupled or welded watertight joints. No solvent or anti-sieze compound shall be used on the joints.

The section of riser pipe that sticks up above ground shall be protected by a steel guard pipe set at least 2 feet into a concrete surface seal. The top of the guard pipe shall have a vented lockable cap. Alternatively, a road box may be installed, if it satisfies the security requirements of the project. Road-box installations must use a watertight seal inside of the riser pipe to prevent surface water from entering the well.

Other materials used for well construction include silica sand, bentonite, cement, and a calibrated tape for length measurements and water-level measurements. Construction materials are generally provided by the drilling subcontractor.

8.0 Method

8.1 Borehole Requirements

The diameter of the borehole must be a minimum of 2 inches greater than the outside diameter of the well screen or riser pipe used to construct the well. This is necessary so that sufficient annular space is available to install filter packs, bentonite seals, and grout seals.

Rotary drilling methods requiring bentonite-based drilling fluids should be used with caution to drill boreholes that will be used for monitoring well installation. The bentonite mud builds up on the borehole walls as a filter cake and permeates the adjacent formation, significantly reducing the permeability of the material adjacent to the well screen.

If water or other drilling fluids have been introduced into the boring during drilling or well installation, samples of these fluids should be obtained and analyzed for chemical constituents that may be of interest at the site.

8.2 Procedure for Construction

8.2.1 After drilling and soil sampling have been completed, the borehole shall be checked for total open depth with a weighted, calibrated tape measure.

8.2.2 If the borehole has been advanced to a depth greater than that of the bottom of the well to be installed, bottom grouting, or bentonite pellet sealing, of the borehole will be required. A heavy plumb bob on a calibrated tape shall be used to determine the total depth of the boring. This depth measurement shall be used with the required bottom elevation of the well screen to calculate the thickness of the grout plug. If bottom grouting is necessary, then provisions should be made to support the screen and riser pipe to prevent them from sinking into the grout. The depth to the top of the grout should be checked often with a weighted tape measure.

8.2.3 The assembled screen and riser or its constituent parts shall be decontaminated with a detergent and water wash and triple deionized water rinse. Steam-cleaning also can be done to decontaminate the well materials. Decontaminated well components should be wrapped in plastic until installed in the boring. All personnel handling the decontaminated well components should exercise great care not to contaminate these components as they are installed in the borehole.

8.2.4 The well screen and riser pipe generally are assembled as they are lowered into the borehole. As the assembled well is lowered, care shall be taken to ensure that it is centered in the hole. In boreholes which are determined to be not plumb, centralizers should be used on the tail pipe below the screen and/or the midpoint and top of the screen. This will assure that the screened portion of the well is centrally located in the borehole with a uniform thickness of sand or filter pack between the screen and the borehole wall. In holes greater than 25 feet in depth, centralizers should be used.

8.2.5 The annular space surrounding the screened section of the monitoring well and at least 1 foot above the top of the screen shall be filled with an appropriately graded, clean sand or gravel. In no case shall the sand pack be longer than 1.5 times the length of the screen. A minimum 1-foot thick layer of very fine sand (i.e., sand-blasting sand) should be placed immediately above the well screen sand pack. This layer is designed to prevent the infiltration of sealing components (bentonite or grout) into the sand pack. As each layer is placed, a weighted tape should be lowered in the annular space to verify the depth to the top of the layer.

Depending on the depth of the well, the diameters of the borehole and well materials, and the depth to the static water level, satisfactory placement of the sand pack may require the use of a tremie pipe.

8.2.6 Bentonite seals, either pellets or slurry, a minimum of 2 feet thick shall be installed immediately above the artificial gravel pack in all monitoring wells. The purpose of the seal is to provide a barrier to vertical flow of water in the annular space between the borehole and the well. Bentonite is used because it swells significantly upon contact with water. Pellets generally can be installed in shallow boreholes by pouring them very slowly from the surface. If they are poured too quickly, they may bridge at some shallow, undesired depth. Powdered bentonite shall be installed by mixing a very thick slurry and using remie pipe to inject the seal material at the desired depth in the borehole. Bentonite slurry should be pumped into the annular space using a side-discharge tremie pipe located about 2 feet above the fine-sand pack. Side discharge will ensure the integrity of the sand pack.

In situations where the monitoring well screen straddles the water table, the seal will be in the unsaturated zone and pure bentonites (pellets or powder) will not work effectively as seals due to dessication. Seals in this situation should be a cement/bentonite mixture containing 2 to 10 percent bentonite by weight. This type of mixture shall be tremied to the desired depth in the borehole.

8.2.7 The remaining length of borehole shall be backfilled with grout to within 2 feet of the ground surface. This grouting will consist of a cement/bentonite mixture. A tremie pipe shall be used to install the grout. Drill cuttings, even those known not to be contaminated, shall not be used as backfill material.

8.2.8 The steel guard-pipe shall be placed around the riser, and the borehole around the guard pipe shall be dug out to approximately a 1-foot radius to a depth of 2 feet, and filled with concrete. The concrete pad shall be sloped so that drainage occurs away from the well. All completed wells will have identification numbers clearly painted on the cap and guard pipe with bright colored paint.

Generally, the protective guard pipe will be lockable. A point on the top of the riser pipe will be marked (paint spot or cut notch) to indicate the surveyed elevation position, known as the "measuring point" (MP).

A vent hole must be installed in the protective casing in an area that is protected from precipitation. Road box installations should not be vented.

8.2.9 Measure the depth to the stabilized water level and record on the ground water monitoring well detail report (shown as Figure 1).

8.2.10 At some point after installation of a well and prior to use of the well for water level measurements or water quality samples, development of the well shall be undertaken in accordance with ENSR SOP 7221, Monitoring Well Development.

9.0 Quality Control Checks and Acceptance Criteria

- The borehole will be checked for total open depth, and extended by further drilling or shortened with a grout plug, if necessary, before any well construction materials are placed.
- Water level will be checked repeatedly during well installation to ensure that the positions of well screen, sand pack and seal, relative to water level, conform to project requirements.
- The depth to the top of each layer of packing (i.e., sand, bentonite, grout, etc.) will be verified and adjusted if necessary to conform to the requirements of this SOP and the QAPP before the next layer is placed.

10.0 Documentation

During installation of each monitoring well, a series of measurements shall be taken and recorded. These measurements shall include:

- length of tail pipe (if used)
- length of screen
- length of riser pipe
- total length of well
- depth to stabilized water level

Other data include the screen and riser pipe materials, diameters of the respective components, screen slot size, type and thickness of the sand pack, thicknesses and different types of grouting materials, and elevation of the top of the guard pipe, established measuring point, and ground surface after surveying is complete. If water or other drilling fluids have been introduced into the boring during drilling or well installation, samples of fluids should be obtained and analyzed for chemical constituents that may be of interest at the site.

All data shall be recorded on site onto the ground water monitoring well detail report (shown as Figure 1) and all wells shall be referenced onto the appropriate site map. A field book and/or boring log can be used as additional means of recording data. In no case shall the field book or boring log take the place of the ground water monitoring well detail report. All documentation shall remain in the project files indefinitely.

Title: Monitoring Well Construction and Installation

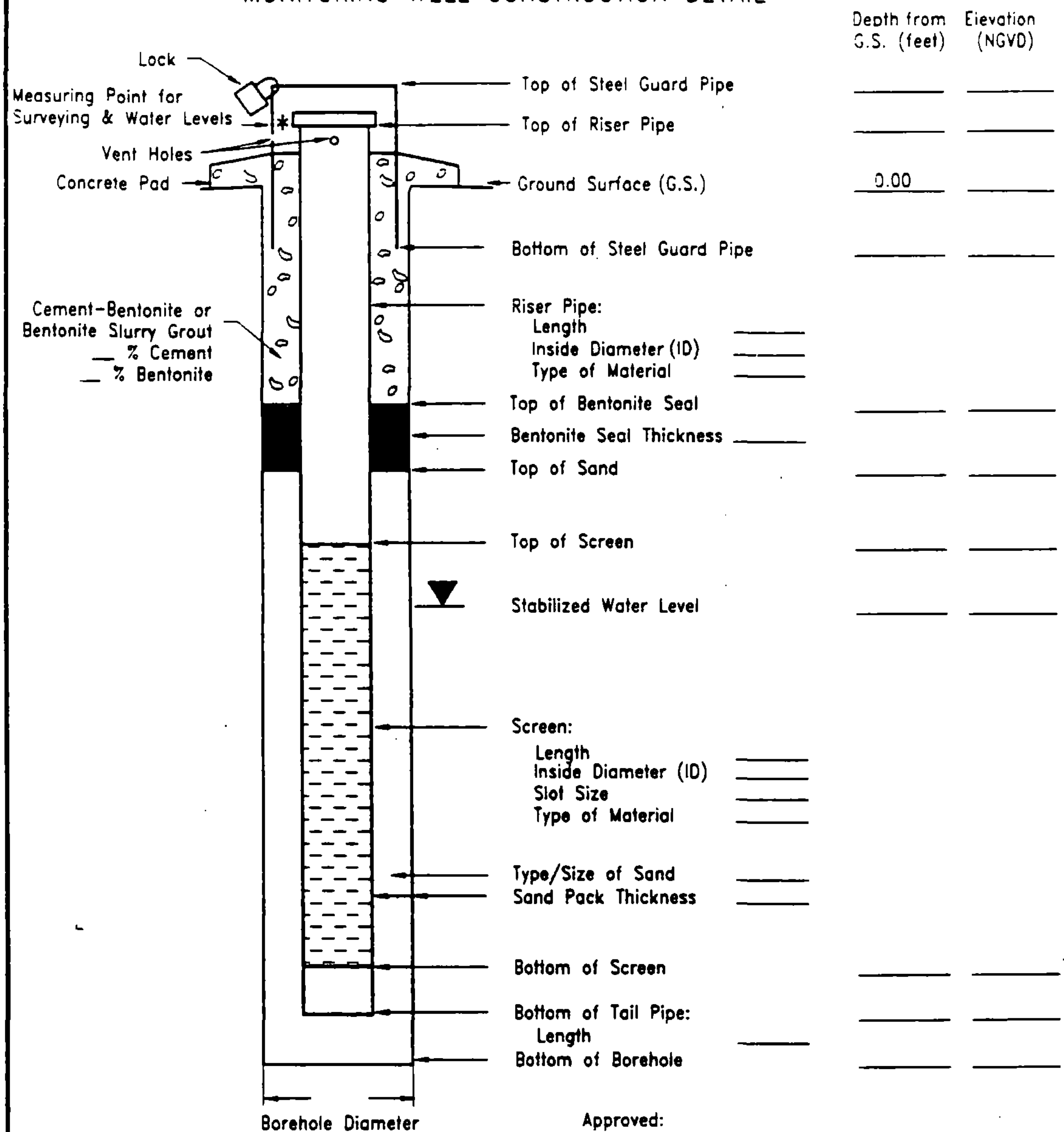
Figure 1

Project No: ______ Client: ______ Site: ______ WELL No:

Well Location: ______ Date Installed: ______

Contractor: ______ Method: ______ Inspector: ______

MONITORING WELL CONSTRUCTION DETAIL



Approved:

* Describe Measuring Point: ______

Signature ______ Date ______

ENSR.

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STANDARD OPERATING PROCEDURES

Number: 7221

Date of Issue: 2nd Qtr. 1989

Title: Monitoring Well Development

Organizational Acceptance	Authorization	Date
Originator	[illegible]	3-23-89
Technical Reviewer	[illegible]	4-10-89
Technical Reviewer	William M. Gregg	4-18-89
Technical Reviewer	[illegible]	5-2-89
Quality Assurance	[illegible]	5-12-89

Revisions No.	Changes	Authorization	Date
0			

1.0 Purpose and Applicability

This SOP describes the methods used for developing monitoring wells after original installation and prior to use of the well for obtaining water level measurements or water quality samples. Development should not be confused with purging, the purpose of which is to evacuate the monitoring well system of stagnant water which may not be representative of the aquifer. For purging procedures refer to ENSR SOP No. 7130, Ground-Water Sample Collection from Monitoring Wells.

Monitoring well development and/or rehabilitation are necessary to ensure that complete hydraulic connection is made and maintained between the well and the aquifer material surrounding the well screen and packing materials. Development is necessary after original installation of a monitoring well to (1) reduce the compaction and inter-mixing of grain sizes produced during drilling; (2) to increase the porosity and permeability of the artificial filter pack by removing the finer grain-size fraction introduced near the screen by drilling and well installation; and (3) to remove any foreign drilling fluids that coat the borehole or that may have invaded the adjacent natural formation.

This procedure applies to monitoring wells in which siltation has been determined to have occurred. After a well has been installed for some period of time (ranging from months to years), siltation of the well may occur and rehabilitation will be necessary to re-establish complete hydraulic connection with the aquifer.

2.0 Definitions

Note: Equipment components are defined in Section 7.0 of this SOP.

Bridging: A condition within the filter pack outside the well screen whereby the smaller particles are wedged together in a manner that causes blockage of pore spaces.

Hydraulic Conductivity: A characteristic property of aquifer materials which describes the permeability of the material to a particular fluid (usually water).

Hydraulic Connection: A properly installed and developed monitoring well should have a complete hydraulic connection with the aquifer. The well screen and filter material should not provide any restriction to the flow of water from the aquifer to the well.

Permeability Test: Used to determine the hydraulic conductivity of the aquifer formation near a well screen. Generally conducted by displacing the water level in a well and monitoring the rate of recovery of the water level as it returns to equilibrium. Various methods of analysis are available to calculate the hydraulic conductivity from these data.

Screened Interval: That portion of a monitoring well that is open to the aquifer.

Static Water Level: The water level in a well that represents an equilibrium condition when the aquifer is not being stressed (no nearby withdrawal or injection of water). Since the ground water conditions are generally dynamic, static is a condition that holds true only for short periods of time (anywhere from minutes to years depending on cultural and climatic influences).

Well Surging: That process of moving water in and out of a well screen to remove fine sand, silt and clay size particles from the adjacent formation.

Well Purging: The process of removing water from a well to allow in situ formation water to enter the well. Generally thought of in terms of removing standing water from a well prior to the collection of water samples for quality determination, the process also is conducted to remove suspended particles from the well after well surging.

Well Screen: That portion of the well casing material that is perforated in some manner so as to provide a hydraulic connection to the aquifer. Typically a well screen has slots but holes, slits, louvers, and other perforations can, in some situations, be used.

3.0 Health and Safety Considerations

Monitoring well development may involve chemical hazards associated with materials in the soil or aquifer being explored; and always involves physical hazards associated with the heavy equipment that may be used for various development techniques. When wells are to be installed and developed in locations where the aquifer and/or overlying materials may contain chemical hazards, a Health and Safety Plan must be prepared and approved by the Health and Safety Officer before field work commences.

In addition, the following protective measures are always required:

- all persons within 50 feet of a drill rig must wear hard hats and safety shoes. Hearing protection should be provided during periods of excessive noise; and
- personnel who are not directly involved in overseeing, inspecting or performing the drilling and well installation will remain at least 100 feet away from the drill rig.

4.0 Quality Assurance Planning Considerations

The appropriate development method will be selected for each project on the basis of the circumstances, objectives and requirements of that project. Further, some states and EPA regions have promulgated comprehensive guidelines for ground water monitoring and subsurface investigation procedures. The provisions of this SOP will be adapted to these project-specific requirements in the Quality Assurance Project Plan (QAPP). Each QAPP will describe the specific method(s) to be used and the rationale, including trade-offs associated with the nature of the aquifer formation, chemical analytical objectives, and client or agency requirements.

5.0 Responsibilities

Development of new monitoring wells is the responsibility of the geologist or hydrogeologist involved in the original installation of the well. The geologist may, in fact, contract with the well driller to develop new wells under the geologist's guidance and oversight. Records of well development methods and results are to be kept by the geologist.

Any person using existing monitoring wells for any purpose is responsible for verifying the original well construction details and determining if a well requires rehabilitation.

6.0 Training/Qualifications

Each ENSR employee who develops a monitoring well for an ENSR project will have been trained by an experienced ENSR geologist in the specific procedure used.

7.0 Supporting Materials

The following list identifies the types of equipment which may be used to develop monitoring wells. Exact equipment needs will be well-specific and will depend upon the diameter of the well, the depth to the static water level and other factors.

7.1 Surge Block

A surge block consists of a rubber (or leather) and metal plunger attached to rod or pipe of sufficient length to reach the bottom of the well. Well drillers usually can provide surge blocks for large diameter wells (greater than 6 inches). Surge blocks for smaller diameter wells can be constructed easily of materials readily accessible in any hardware store. A recommended design is shown in Figure 1. To reduce cross-contamination of monitoring wells, a new plunger generally is used in each well to be developed and the rod is decontaminated in accordance with procedures in ENSR SOP 7600, Decontamination of Equipment.

7.2 Pump

A pump is necessary to remove large quantities of silt-laden ground water from a well after using the surge block. In some situations, the pump alone is used to both surge the well and remove the fines. Since the purpose of well development is to remove suspended solids from a well, the pump must be capable of moving some solids without damage. The preferred pump is a centrifugal because of its ability to pump solids, but a centrifugal pump will work only where the depth to static ground water is less than approximately 25 feet. In deep ground water situations, a positive-displacement pump such as a submersible or bladder pump will be necessary.

7.3 Bailer

A bailer is to be used to purge silt-laden water from wells after using the surge block. In some situations, the bailer can be used to surge a well but the use of a bailer for surging is not recommended. The bailer is to be used for purging in situations where the depth to static water is greater than 25 feet and the silt loading is greater than that which can be handled by positive-displacement pumps.

7.4 Compressed Gas

Compressed gas, generally nitrogen, can be used to both surge and purge a monitoring well. A nitrogen tank is used to inject gas at the bottom of the water column, driving sediment-laden water to the surface. Compressed gas can also be used for "jetting" - a process by which the gas is directed at the slots in the well screen to cause turbulence (thereby disturbing fine materials in the adjacent filter pack). Compressed gas is not limited to any depth range.

The hose or pipe which will be installed in the well for jetting should be equipped with a horizontal (side) discharge nozzle and one or more small holes in the bottom of the hose to enhance the lifting of sediment during jetting.

Since the compressed gas will be used to "lift" water from the monitoring well, provisions must be made for controlling the discharge from contaminated wells. This is generally accomplished by attaching a "tee" discharge to the top of the casing and providing drums to contain the discharged water. Gas-lifting must never be done in contaminated wells without providing discharge control apparatus.

7.5 Decontamination Equipment

Standard equipment for decontaminating field apparatus in accordance with ENSR SOP 7600 will be used to decontaminate all equipment used to develop monitoring wells.

7.6 Purge Water and Sediment Disposal

The QAPP must specify the means for disposing of purged sediment-laden water. In most cases, disposal of this material will follow the methods used in the original installation of the borehole. If soil and/or ground water contamination conditions in a well have changed, it may be necessary to specify new disposal methods for wells that are being re-developed.

7.7 Monitoring Well Construction Details

A copy of the original Monitoring Well Construction Detail form for the well to be developed must be obtained from the project manager. This form provides critical information regarding the construction of the monitoring well and must be in the possession of the well development crew so that pertinent well construction details, such as total depth, are known.

7.8 Supporting SOPs

- 7130 - Ground-Water Sample Collection from Monitoring Wells
- 7220 - Monitoring Well Construction and Installation
- 7600 - Decontamination of Equipment
- 7720 - Rising-Head/Falling-Head Permeability Testing

8.0 Procedure for Well Development

8.1 General Procedure

8.1.1 Conduct a permeability test as described in ENSR SOP 7720 to determine the hydraulic conductivity of the screened interval. The results of this test, along with other tests conducted during the development process, will be used to evaluate the success of the development.

8.1.2 Water is caused to move in and out through the monitoring well screen to move silt and clay particles out of the filter pack around the well screen and into suspension within the well. Water movement is effected using a surge block, bailer, or a compressed gas. In some situations, pumping water may effect satisfactory development, but pumping alone is not generally recommended.

8.1.3 The sediment-laden water is removed from the monitoring well using a pump, bailer, or air compressor.

8.1.4 Surging of the well is continued until the water removed is essentially free of suspended silt and clay particles. During the surging/purging cycles, a permeability test should be performed as described in ENSR SOP 7720 to monitor and evaluate the development process.

8.1.5 Generally, a permeability test as described in ENSR SOP 7720 is used to confirm that a reliable hydraulic connection has been established (or re-established) between the well and the surrounding aquifer material.

8.2 Selection of a Specific Procedure

The construction details of the well can be used to initially define the method of purging a well with due consideration being given to the level of contamination.

The criteria for selecting a well development method include well diameter, total well depth, static water depth, screen length, the likelihood and level of contamination, and the type of geologic formation adjacent to the screened interval.

The limitations, if any, of a specific procedure are discussed within each of the following procedures.

Methods that involve placing water into the well may be objectionable to some state and federal agencies. In such cases the surge block procedure may be preferable over the pumping procedure.

8.3 Specific Procedure: Surge Block

8.3.1 A surge block effectively develops most monitoring wells. If the geologic layering in the screened interval includes permeable and impermeable layers (e.g., gravels and clays), it is possible that surging could remove fines from the impermeable layers and force them into the permeable layers. This problem can be minimized by using fewer surging cycles, using a surge block which is looser fitting and/or increasing the purging volume or time of development.

8.3.2 Construct a surge block using the design in Figure 1 as a guide. Specific materials will depend upon the diameter of well to be developed. The diameter of the flexible rings must be sufficient to cause a tight seal within the well casing, and the rods must be of sufficient length to reach to the bottom of the monitoring well.

8.3.3 Insert the surge block into the well and lower it slowly to the level of static water. Start the surge action slowly and gently above the well screen using the water column to transmit the surge action to the screened interval. A slow initial surging, using plunger strokes of 3 to 5 feet, will allow material which is blocking the screen to separate and become suspended.

8.3.4 After a number (5 to 10) of plunger strokes, remove the surge block and purge the well using a pump or bailer. The returned water should be heavily laden with suspended silt and clay particles. As development continues, slowly increase the depth of surging to the bottom of the well screen. For monitoring wells with long screens (greater than 10 feet) surging should be undertaken along the entire screen length in short intervals (2 to 3 feet) at a time.

8.3.5 Continue this cycle of surging and purging until the water yielded by the well is free of visible suspended material.

8.4 Specific Procedure: Pump

8.4.1 Well development using only a pump is most effective in those monitoring wells that will yield water continuously. Effective development cannot be accomplished if the pump has to be shut off to allow the well to recharge.

8.4.2 Set the intake of the pump in the center of the screened interval of the monitoring well.

8.4.3 Pump a minimum of three well volumes of water from the well while using the intake hose of the pump as a plunger. The motion of the intake hose will act to a limited extent as a surge block.

8.4.4 Occasionally, where appropriate, use the pump to fill the monitoring well to the top of the casing and allow the water level to decline to the static level, thereby forcing water back into the formation. This action will cause water to exit the well screen and reduce the bridging of materials caused by water flowing in one direction through the well screen while pumping.

The water used to fill the monitoring well should be the same water removed from the well during the previous pumping cycle. The sediment previously pumped from the well must be removed from the water prior to re-introduction to the well. A steel drum can be used as a sediment-settling vessel.

8.4.5 Continue pumping water into and out from the well until sediment-free water is obtained.

8.5 Specific Procedure: Bailer

8.5.1 Lower the bailer into the screened interval of the monitoring well.

8.5.2 Using long, slow strokes, raise and lower the bailer in the screened interval simulating the action of a surge block.

8.5.3 Periodically bail standing water from the well to remove silt and clay particles drawn into the well.

8.5.4 Continue surging the well using the bailer and bailing water from the well until sediment-free water is obtained.

8.6 Specific Procedure: Compressed Gas (Nitrogen)

8.6.1 Although the equipment used to develop a well using this method is more difficult to handle and use, well development using compressed gas for jetting is considered to be a very effective method. This method also is the most generally applicable because it is not limited by well depth, well diameter or depth to static water, but caution must be exercised in highly permeable formations not to inject gas into the formation.

8.6.2 Lower the gas line from the gas cylinder into the well, setting it near the bottom of the screened interval. Install the discharge control equipment at the well head.

8.6.3 Set the gas flow rate to allow continuous discharge of water from the well. The discharge will contain suspended clay and silt material.

8.6.4 At intervals during gas-lifting, especially when the discharge begins to contain less suspended material, shut off the air flow and allow the water in the well to flow out through the screened interval to disturb any bridging that may have occurred. Re-establish the gas flow when the water level in the well has returned to the pre-development level.

8.6.5 Jetting of the screened interval also can be done during gas-lifting of water and sediment from the well. This is accomplished by using a lateral-discharge nozzle on the gas pipe or hose and slowly moving the nozzle along the length of the screened interval. Jetting should be done beginning at the bottom of the well screen and moving slowly upwards along the screened interval. To enhance gas lifting of sediment, occasionally raise the discharge nozzle into the cased portion of the well and discharge sediment-laden water.

8.6.6 Continue gas-lifting and/or jetting until the water returned in the air stream is free from suspended material.

9.0 Quality Control Checks

A well has been successfully developed when one or more of the following criteria are met:

- the well yields only clear, sediment-free water.
- two or more permeability tests in accordance with ENSR SOP 7720 yield repeatable hydraulic conductivity values.
- the original depth of the well, as described on the Monitoring Well Construction Detail form in ENSR SOP 7220, is clear of sediment and that depth is maintained for some period of time (longer than hours, probably less than one year).

10.0 Documentation

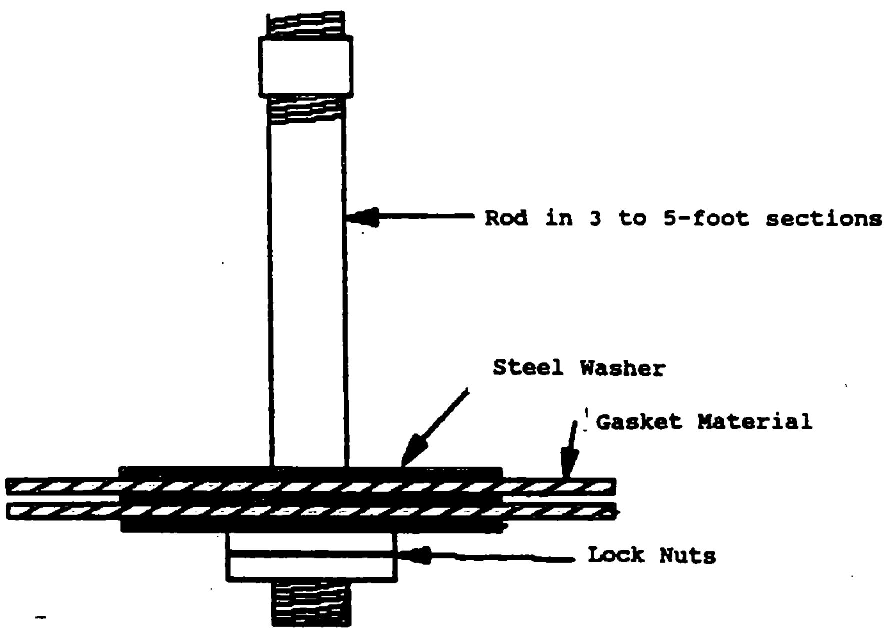
The Monitoring Well Development Record (Figure 2) will be completed by the geologist or hydrogeologist conducting the development. In addition, a field log book should be maintained detailing any problems or unusual conditions which may have occurred during the development process. Any inability to return the well to the original specifications will be noted on the original copy of the Monitoring Well Construction Detail form and on the Monitoring Well Development Record (Figure 2).

All documentation will be retained in the project files following completion of the project.

Figure 1

SURGE BLOCK DESIGN

Steel washers should be 1/2" to 3/4" smaller diameter than the well ID. Gasket can be rubber or leather and should be the same diameter or 1/8" smaller than the well diameter to compensate for swelling of the leather. Rod can be steel, fiberglass, or plastic but must be strong and lightweight.



NOT TO SCALE

ENSR CONSULTING & ENGINEERING

Figure 1
Surge Block Design

TMC	11/10/88	SOP 7221

ENSR

MONITORING WELL DEVELOPMENT RECORD

DATE: ______________________ WELL I.D.: ______________________

PROJECT NAME: ______________________ LOCATION: ______________________

PROJECT NUMBER: ______________________ DEVELOPER: ______________________

☐ ORIGINAL DEVELOPMENT ☐ REDEVELOPMENT ORIGINAL DEVELOPMENT DATE: __________

WELL DATA

Well Diameter	
Total Well Depth	
Depth to Top of Screen	
Depth to Bottom of Screen	
Depth to Static Water Level	

Geology at Screened Interval

Likely Contaminants

Purge Water and Sediment Disposal Method

DEVELOPMENT METHOD	PURGING METHOD	PERMEABILITY TEST RESULTS

ACCEPTANCE CRITERIA

Signature ______________________ Date __________

M890322

Figure 2

ENSR

MONITORING WELL DEVELOPMENT RECORD

DATE: ______ WELL I.D.: ______

PROJECT NAME: ______ LOCATION: ______

PROJECT NUMBER: ______ DEVELOPER: ______

☐ ORIGINAL DEVELOPMENT ☐ REDEVELOPMENT ORIGINAL DEVELOPMENT DATE: ______

WELL DATA

Well Diameter		Geology at Screened Interval	
Total Well Depth			
Depth to Top of Screen		Likely Contaminants	
Depth to Bottom of Screen			
Depth to Static Water Level		Purge Water and Sediment Disposal Method	

DEVELOPMENT METHOD	PURGING METHOD	PERMEABILITY TEST RESULTS

ACCEPTANCE CRITERIA

Signature ______ Date ______

M890322

ENSR **STANDARD OPERATING PROCEDURE**

Number: 7510 **Date of Issue:** 2nd Qtr.1993

Revision: 2

Title: Packaging and Shipment of Samples

Organizational Acceptance	Authorization	Date
Originator	Christopher Carlio	3/13/84
Technical Reviewer	Arthur Lazarus	3/13/84
Technical Reviewer	Elaine Moore	3/13/84
Technical Reviewer		
Quality Assurance	Scott Whittemore	3/13/84

Revision #	Changes	Authorization	Date
1	• Chain-of-Custody procedure for hinged coolers added	Scott Whittemore Elaine Moore	9/19/86 10/13/86
	• Miscellaneous rewording		
2	• Format update	Mike Dobrowolski	4/27/93
	• Chain-of-Custody form update		

Organizational acceptance signatures are maintained on file with the original document in the Quality Assurance Library in Acton, MA.

ENSR Consulting and Engineering

Packaging and Shipment of Samples

Date:	2nd Qtr. 1993
Revision No:	2
Author:	Christopher Carlio
Discipline:	Geosciences

1.0 PURPOSE AND APPLICABILITY

This Standard Operating Procedure (SOP) describes the procedures associated with the packaging and shipment of samples. Two general categories of samples exist: environmental samples consisting of air, water and soil; and waste samples which include non-hazardous solid wastes and hazardous wastes as defined by 40 CFR Part 261.

2.0 RESPONSIBILITIES

2.1 Project Manager

It is the responsibility of the project manager to assure that the proper packaging and shipping techniques are utilized for each project.

2.2 Field Team Leader

The field team leader shall be responsible for the enactment and completion of the packaging and shipping requirements outlined in the project specific sampling plan. The field team leader shall be responsible to research, identify and follow all applicable U.S. Department of Transportation (DOT) regulations regarding shipment of materials classified as waste.

3.0 REQUIRED MATERIALS

- Sample cooler
- Bubble wrap
- "Blue Ice" refreezable ice packs
- Fiber tape

- Zip lock plastic bags

4.0 METHOD

The objective of sample packaging and shipping protocol is to identify standard procedures which will minimize the potential for sample spillage or leakage and maintain field sampling program compliance with U.S. EPA and U.S. DOT regulations.

The extent and nature of sample containerization will be governed by the type of sample, and the most reasonable projection of the sample's hazardous nature and constituents. The EPA regulations (40 CFR Section 261.4(d)) specify that samples of solid waste, water, soil or air, collected for the sole purpose of testing, are exempt from regulation under the Resource Conservation and Recovery Act (RCRA) when all of the following conditions are applicable:

- Samples are being transported to a laboratory for analysis;

- Samples are being transported to the collector from the laboratory after analysis;

- Samples are being stored (1) by the collector prior to shipment for analyses, (2) by the analytical laboratory prior to analyses, (3) by the analytical laboratory after testing but prior to return of sample to the collector or pending the conclusion of a court case.

Qualification for transportation as described above require that sample collectors comply with U.S. DOT and U.S. Postal Service (USPS) regulations. If U.S. DOT and USPS regulations are found not to apply, the following information must accompany all samples and will be entered on a sample specific basis on chain of custody records:

- sample collector's name, mailing address and telephone number,

- analytical laboratory's name, mailing address and telephone number,

- quantity of sample,

- date of shipment,

- description of sample, and

In addition, all samples must be packaged so that they do not leak, spill or vaporize.

4.1 Place plastic bubble wrap matting over the base and bottom corners of each cooler or shipping container as needed to manifest each sample.

4.2 Obtain a chain of custody record as shown in Figure 1 and enter all the appropriate information as discussed above. Chain of custody records will include complete information for each sample. One or more chain of custody records shall be completed for each cooler or shipping container as needed to manifest each sample.

4.3 Wrap each sample bottle individually and place standing upright on the base of the appropriate cooler, taking care to leave room for some packing material and ice or equivalent. Rubber bands or tape should be used to secure wrapping, completely around each sample bottle.

4.4 Place additional bubble wrap and/or styrofoam pellet packing material throughout the voids between sample containers within each cooler.

4.5 Place ice or cold packs in heavy duty zip-lock type plastic bags, close the bags, and distribute such packages over the top of the samples. Add additional bubble wrap/styrofoam pellets or other packing materials to fill the balance of the cooler or container.

4.6 Obtain two pieces of chain of custody tape as shown in Figure 2 and enter the custody tape numbers in the appropriate place on the chain of custody form. Sign and date the chain of custody tape.

4.7 To complete the chain of custody form enter the type of analysis required for each sample, by container, under the "ANALYSES" section. Under the specific analysis enter the quantity/volume of sample collected for each corresponding analysis.

4.8 If shipping the samples where travel by air or other public transportation is to be undertaken, sign the chain of custody record thereby relinquishing custody of the samples. Relinquishing custody should only be performed when directly transmitting custody to a receiving party or when transmitting to a shipper for subsequent receipt by the analytical laboratory. Shippers should not be asked to sign chain of custody records.

4.9 Remove the last copy from the chain of custody record and retain with other field notes. Place the original and remaining copies in a zip-lock type plastic bag and place the bag on the top of the contents within the cooler or shipping container.

4.10 Close the top or lid of the cooler or shipping container and with another person rotate/shake the container to verify that the contents are packed so that they do not move. Improve the packaging if needed and reclose.

4.11 Place the chain of custody tape at two different locations on the cooler or container lid and overlap with transparent packaging tape. For coolers with hinged covers, if the hinges are attached with screws, chain of custody tape should also be used on the hinge side.

4.12 Packaging tape should be placed entirely around the sample shipment containers. A minimum of two full wraps of packaging tape will be placed at least two places on the cooler. Shake the cooler again to verify that the sample containers are well packed.

4.13 When transporting samples by automobile to the laboratory, and where periodic changes of ice are required, the cooler should only be temporarily closed so that reopening is simple. In these cases, chain of custody will be maintained by the person transporting the sample and chain of custody tape need not be used. If the cooler is to be left unattended, then chain of custody procedures should be enacted.

4.14 If shipment is required, transport the cooler to an overnight express package terminal or arrange for pickup. Obtain copies of all shipment records as provided by the shipper.

4.15 If the samples are to travel as luggage, check with regular baggage.

4.16 Upon receipt of the samples, the analytical laboratory will open the cooler or shipping container and will sign "received by laboratory" on each chain of custody form. The laboratory will verify that the chain of custody tape has not been broken previously and that the chain of custody tape number corresponds with the number on the chain of custody record. The analytical laboratory will then forward the back copy of the chain of custody record to the sample collector to indicate that sample transmittal is complete.

5.0 QUALITY CONTROL

Not Applicable

6.0 DOCUMENTATION

As discussed in Section 4.0 the documentation for supporting the sample packaging and shipping will consist of chain of custody records and shipper's records. In addition a description of sample packaging procedures will be written in the Field Log Book. All documentation will be retained in the project files following project completion.

M901376

ENSR

CHAIN OF CUSTODY RECORD

Page ____ of ____

Client/Project Name:	Project Location:
Project Number:	Field Logbook No.:
Sampler: (Print Name) /Affiliation:	Chain of Custody Tape No.:
Signature:	Send Results/Report to:

Analysis Requested

Field Sample No./ Identification	Date	Time	Grab	Comp	Sample Container (Size/Mat'l)	Sample Type (Liquid, Sludge, Etc.)	Preservative	Field Filtered							Lab I.D.	Remarks

Relinquished by: (Print Name) Signature:	Date: Time:	Received by: (Print Name) Signature:	Date: Time:	Analytical Laboratory (Destination):
Relinquished by: (Print Name) Signature:	Date: Time:	Received by: (Print Name) Signature:	Date: Time:	
Relinquished by: (Print Name) Signature:	Date: Time:	Received by: (Print Name) Signature:	Date: Time:	Serial No. 6118

ENSR

Date ______________________

Sig. ______________________

№ 002233

ENSR

STANDARD OPERATING PROCEDURE

Number: 7600 **Date of Issue:** 2nd Qtr.1993

Revision: 3

Title: Decontamination of Field Equipment

Organizational Acceptance	**Authorization**	**Date**
Originator	Charles Martin	3/2/84
Technical Reviewer	Arthur Lazarus	3/2/84
Technical Reviewer	Elaine Moore	3/2/84
Technical Reviewer		
Quality Assurance	Scott Whittemore	3/2/84

Revision #	Changes	Authorization	Date
1	Update	Charles Martin Arthur Lazarus Elaine Moore Scott Whittemore	3/2/84 3/2/84 3/2/84 3/2/84
2	• Addition of Health and Safety Considerations, Quality Assurance Planning Considerations, Training Requirements, QA/QC Checks, and Documentation sections • Addition of nitric acid wash for metals analyses • Addition of heavy equipment decontamination protocol • Miscellaneous edits and updates	Charles Martin Ken Fossey Mike Dobrowolski	3/12/90 4/3/90 5/3/90
3	Format update	Mike Dobrowolski	4/27/93

Organizational acceptance signatures are maintained on file with the original document in the Quality Assurance Library in Acton, MA.

SOP NO: 7600

ENSR ENSR Consulting and Engineering

Decontamination of Field Equipment

Date: 2nd Qtr. 1993

Revision No: 3

Author: Charles Martin

Discipline: Geosciences

1.0 PURPOSE AND APPLICABILITY

1.1 This SOP describes the methods to be used for the decontamination of all field equipment which may become contaminated or act as a contamination source during a sample collection task. The equipment may include split-spoon samplers, bailers, trowels, shipping coolers, drill rigs, backhoes, or any other type of equipment used during field activities.

Decontamination is performed as a quality assurance measure and a safety precaution.

- Improperly decontaminated sampling equipment can lead to misinterpretation of environmental data due to interference caused by cross-contamination.
- Decontamination protects field personnel from hazardous materials and protects the community by preventing uncontrolled transportation of contaminants at or from a site.

1.2 Decontamination is accomplished by manually scrubbing, washing, or spraying equipment with detergent solutions, tap water, distilled/deionized water, steam, or solvents. Equipment will be allowed to air dry after being decontaminated or may be wiped dry with chemical-free paper towels if immediate use is necessary.

The decontamination method and agents are to be determined on a project specific basis and must be stated in the Quality Assurance Project Plan (QAPP).

1.3 The frequency of equipment use dictates that most decontamination be accomplished at each sampling site between collection points. All cleaning materials and wastes should be stored in a central location so as to maintain control over the quantity of materials used or produced throughout the study. Decontamination waste products such as liquids, solids, rags, gloves, etc., will be collected and disposed of as specified in the QAPP.

1.4 Health and Safety Considerations

Decontamination procedures may involve;

- chemical exposure hazards associated with the medium being explored or solvents employed and may also involve;

- physical hazards associated with decontamination equipment.

When decontamination is performed on equipment which has been in contact with hazardous materials or when the quality assurance objectives of the project require decontamination with chemical solvents, the measures necessary to protect personnel must be addressed in the Health and Safety Plan.

The Health and Safety Plan must be approved by the project Health and Safety Officer before work commences, must be distributed to all personnel performing equipment decontamination and must be adhered to as field activities are performed.

1.5 Quality Assurance Planning Considerations

The following topics must be considered and addressed during the formulation of a decontamination strategy and should be outlined in the Quality Assurance Project Plan (QAPP). Each are dependent on site logistics, site-specific chemistry, the nature of the contaminated media and the objectives of the study.

- decontamination method

- solvent

- frequency

- location on site

- the method of containment and disposal of decontamination wash solids and solutions and

- state and local agency specific requirements for the selection of solvents and decontamination procedures.

1.5.1 The ideal situation would be to have all sampling equipment such as bailers, trowels and shovels laboratory decontaminated and dedicated to one sampling location for each day of sampling.

1.5.2 Laboratory decontamination may not be a practical option, however, depending on the scope of the project. It may be to expensive to obtain laboratory decontaminated sampling devices for short-term projects or projects which have numerous sampling locations. Sampling equipment such as split-spoon samplers or hand augers are too large to have laboratory cleaned. Finally, it may be difficult to schedule the necessary laboratory procedures.

1.5.3 There are several factors which need to be considered when deciding upon a decontamination solvent:

- the solvent should not be an analyte of interest;
- the solvent must be relatively stable so that it can be handled and stored in the field without special handling requirements;
- all sampling equipment must be resistant to the solvent;
- the solvent must be evaporative or water soluble or preferably both;
- state or local agencies may have specific requirements regarding decontamination solvents; and
- ,the analytical objectives of the study.

1.5.4 Methanol is the solvent of choice for general organic analyses. It is relatively safe and effective. A 10% nitric acid in deionized water solution is the solvent of choice for general metals analyses. Nitric acid use is restricted to use on Teflon, plastic or glass equipment.

1.5.5 If used on metal equipment, nitric acid will eventually corrode the metal and lead to the introduction of metals to the collected samples. If it is necessary to use metal sampling equipment for metals sampling, the procedure for decontamination will be:

- a non-phosphate detergent wash
- a tap water rinse
- a double distilled/deionized water rinse

State or local agencies may take exception to this procedure and require an acid wash. If this is the case, it must be recognized that the use of nitric acid on metal sampling equipment may lead to analytical interferences.

1.5.6 Decontamination should be performed far enough away from the source of contamination so as not to be affected by the source but close enough to the sampling site to keep handling to a minimum.

1.5.7 If heavy equipment such as drill rigs or backhoes are to be decontaminated, then a central decontamination station should be considered. Power may be required to run steam generators or high pressure water pumps. A water source may also be necessary. The construction of a sealed concrete pad with drains and walls, or other suitable temporary structure, to contain sprays and splashes may be necessary. Rinse and wash solutions should be collected and contained in 55 gallon metal or plastic drums.

1.5.8 Depending on the nature of the contaminated media or the decontamination solvents utilized, it may be necessary to collect and dispose of all particulate matter and wash solutions. If containment is necessary it may be achieved by performing the decontamination in large galvanized tubs or over plastic sheeting.

1.5.9 Upon review of the analytical data generated from the sampling program, the proper disposal method of these waste products will be determined.

2.0 RESPONSIBILITIES

2.1 It is the responsibility of the project manager to ensure that the proper decontamination procedures are followed and that all waste products of decontamination are properly stored and disposed.

2.2 It is the responsibility of the project safety officer to design and effect safety measures which provide the best protection for all persons involved directly with sampling and/or decontamination.

2.3 It is the responsibility of any subcontractors (i.e., drilling contractors) to follow the proper, designated decontamination procedures that are stated in their contracts and outlined in the project QA and/or Health and Safety Plan.

2.4 It is the responsibility of all personnel involved with sample collection or decontamination to adhere to the decontamination requirements and procedures in this SOP and in project specific Health and Safety Plans and QA plans, to maintain a clean working environment and to reasonably assure that contaminants are not negligently introduced to the environment.

3.0 REQUIRED MATERIALS

Decontamination agents may include: LIQUI-NOX or other phosphate-free biodegradable detergent solutions, tap water, distilled/deionized water, nitric acid, methanol, isopropanol, acetone or other appropriate solvent as specified in the QAPP.

- Personal protective equipment (defined in project Health and Safety Plan)
- Chemical-free paper towels
- Disposable gloves
- Waste storage containers: drums, boxes, plastic bags
- Cleaning containers: plastic buckets, galvanized steel pans, plastic (nalgene or equivalent) upright cylinder
- Cleaning brushes

- High pressure water or steam generator (if necessary)
- Plastic sheeting
- Plastic water storage containers

4.0 METHOD

4.1 General Procedures

4.1.1 The purpose of decontamination is three-fold.

- The first is to ensure that any compounds or contaminants which have been determined through chemical analyses to be present in a sample are in fact native to the sample.

  All sampling equipment such as bailers, trowels, shovels, tape measures, split-spoon samplers, dredges, sample containers, sample shipment coolers, etc., must be decontaminated before use to ensure that contaminants have not been introduced to the sample during the sampling process.

- The second purpose of decontamination is to minimize the exposure of sampling personnel to hazardous materials.

- The third purpose of decontamination is to prevent the introduction of new contaminants to a sampling site or prevent the transportation of compounds or contaminants from the site.

  Heavy equipment such as trucks, drilling rigs and backhoes should be decontaminated upon arrival at the site to prevent the introduction of road chemicals or contaminants from a previous site. Monitoring well riser pipes, screens and drilling augers must also be decontaminated to prevent the introduction of contaminants.

It should be assumed that all sampling equipment, including gloves, are contaminated until the proper decontamination procedures have been performed on them and that contaminated equipment can lead to invalid analytical results.

4.1.2 Unless the decontaminated equipment or construction materials are to be used immediately, they should be wrapped in aluminum foil, shiny side out, and stored in a designated "clean" area. Field equipment can also be stored in plastic bags to eliminate the potential for contamination.

Field equipment should be inspected and decontaminated prior to use if the equipment has been stored for long periods of time.

If customized procedures are not stated in the QAPP the standard procedures specified below shall be followed.

4.2 Decontamination for Organic Analyses

4.2.1 Determine from the QAPP the method of containment for the particulate and wash solution products of decontamination. Typically, smaller equipment will be decontaminated in a plastic or galvanized tub. The brush and container used for the decontamination process should be treated in the same manner as sampling equipment in steps 4.2.2 through 4.2.10.

4.2.2 Decontamination is to be performed before sampling events and between sampling points.

4.2.3 Remove all solid particles from the equipment or material by brushing and then rinsing with available tap water. This initial step is performed to remove gross contamination.

Depending on the size of the equipment being decontaminated, this may be preceded by a steam or high pressure water rinse to remove solids and/or residual oil or grease.

See Section 4.5 for decontamination of heavy equipment.

4.2.4 Wash the equipment or sampler with LIQUI-NOX or other phosphate-free detergent solution.

4.2.5 Rinse with tap water or distilled/deionized water until all detergent and other residue is washed away. Rerinse if necessary or repeat previous steps as necessary.

4.2.6 Rinse with methanol or other appropriate solvent. The solvent to be used should be specified in the QAPP.

4.2.7 Rinse with deionized water to remove any residual solvent.

4.2.8 Allow the equipment or material to air-dry in a clean area or wipe with chemical-free paper towels before use.

4.2.9 Dispose of soiled materials and wash solutions in the designated disposal containers.

4.3 Decontamination for Metals Analyses

4.3.1 For Teflon, plastic and glass, follow the procedures outlined in 4.2, however, use a 10% nitric acid solution as the solvent rinse in step 4.2.7.

4.3.2 For metal equipment, follow steps 4.2.1 through 4.2.6 and allow the equipment or material to air dry in a clean area or wipe with chemical-free paper towels before use.

4.4 Decontamination of Submersible Pumps

4.4.1 This procedure will be used to decontaminate submersible pumps before and between ground-water sample collection points as well as the end of each day of use. If different pumps are used, consult the QAPP for specific decontamination procedures.

4.4.2 During decontamination the submersible pump will be placed on a decontaminated surface, such as a plastic sheet.

4.4.3 When removing the submersible pump from each well the power cord and discharge line will be wiped dry using chemical-free disposable towels. Should the pump be fitted with a disposable discharge line, disconnect the line and dispose of it.

4.4.4 Clean an upright plastic-nalgene cylinder first with a methanol, 10% nitric acid or other specified solvent and then a distilled/deionized water rinse, wiping the free liquids after each.

4.4.5 For reversible pumps, reverse the pump to backwash all removable residual water present in the pump tubing. The pump should be shut off as soon as intermittent flow is observed from the reverse discharge.

4.4.6 Rinse the stainless steel submersible down hole pump section with a detergent solution followed by a water rinse and a liberal application of the specified solvent.

4.4.7 Place the submersible pump section upright in the cylinder and fill the cylinder with tap water, adding 50-100 ml of specified solvent for every one liter of water.

4.4.8 Activate the pump in the forward mode, withdrawing water from the cylinder.

4.4.9 Continue pumping until the water in the cylinder is pumped down and air is drawn through the pump. At this time air pockets will be observed in the discharge line. Shut off the pump immediately.

4.4.10 Remove the pump from the cylinder and place the pump in the reverse mode to discharge all removable water into a disposal container.

4.4.11 Using the water remaining in the cylinder, rinse the sealed portion of the power cord and discharge tube by pouring the water carefully over the coiled lines.

4.4.12 On reaching the next monitoring well, place the pump in the well casing and wipe dry both the power and discharge lines with a chemical-free paper towel as the pump is lowered.

4.5 Decontamination of Heavy Equipment

4.5.1 Upon arrival and prior to leaving a sampling site, all heavy equipment such as drill rigs, trucks, and backhoes should be thoroughly cleaned. This can be accomplished in two ways, steam cleaning or high pressure water wash and manual scrubbing.

4.5.2 Consult the QAPP for instruction on the location of the decontamination station and the method of containment of the wash solutions. Depending on the scope of the project it may be necessary to construct a sealed cement pad with draining capabilities and walls, or other suitable temporary structure, to contain splashes and sprays. A water supply and power source would also be required.

4.5.3 Following the initial cleaning, only those parts of the equipment which come in close proximity to sampling activity should be decontaminated in between sampling events. This would include items such as the backhoe bucket and extension arm.

5.0 QUALITY CONTROL

Necessary quality control checks and acceptance criteria are dependent on site specific chemistry, the nature of the media sampled and the objectives of the study. These checks shall be determined on a project specific basis and shall be outlined in the QAPP or project work plan.

5.1 General guidelines for the quality control checks for decontamination of field equipment are as follows:

- the collection of at least one field blank from the decontaminated equipment per day.

- For the sampling of soils and other solids, a solid field blank is not collected. Instead, decontamination rinsate samples should be collected as field blanks. Although the matrices differ, this water decontamination rinsate sample will provide an indication of the potential contamination due to inadequate decontamination procedures or ambient conditions.

- one shipping blank should accompany each shipment of aqueous samples destined for volatile organic analyses.

In this manner, a qualitative, and in the case of field blanks, quantitative assessment of potential contamination, and of effectiveness of the decontamination process is obtained.

5.2 Field Blanks

5.2.1 Field blanks are prepared for water sampling by pouring laboratory supplied deionized water into or over the freshly decontaminated sampling equipment (bailer, water level measurement tape, etc.) and then transferring this water into a sample container.

- Field blanks should be collected in the same location that samples are collected to determine if ambient VOCs are impacting the samples.

- Sample containers should be filled to the same levels as the samples the blanks are intended to represent.

- Field blanks should be labeled as a sample and submitted to the laboratory to be analyzed for the same parameters as the associated sample.

- Field blank sample numbers, as well as collection method, time and location should be recorded in the field notebook.

5.2.2 Field blanks should also be collected following the decontamination of submersible pumps.

- The pump should be used to withdraw laboratory supplied deionized water from the container and fill a sample container.

- The pump field blank should then be treated as in 4.2.1.

5.2.3 For soil and other solid samples, a solid field blank is not collected. Instead decontamination rinsate samples should be collected. Immediately following the decontamination of the soil sampling equipment (trowel, shovel, split-spoon samplers, dredge, etc.), laboratory supplied deionized water shall be applied to the entire sampler with a squirt bottle and then collected in a sample container.

- Sample containers should be filled to the same levels as the samples the rinsates are intended to represent.

- Decontamination rinsates should then be labeled as a sample and submitted to the laboratory to be analyzed for the same parameters as the associated samples.

- Decontamination rinsate sample numbers, as well as collection method, time and location should be recorded in the field notebook.

5.3 Shipping Blanks

5.3.1 Shipping blanks are used to identify errors introduced by cross-contamination of samples during shipping, sample bottle preparation and blank water quality.

- Analysis of shipping blanks is restricted to volatile compounds because these compounds demonstrate the greatest capacity for migration.

- Shipping blanks are sample containers which are filled with deionized water in the laboratory and placed in the sample shipping coolers when the sampling kits are assembled.

- They remain in the coolers in the field and are not opened.

- They are returned to the laboratory with the collected samples and analyzed for the same parameters as the associated samples.

- The volume of each shipping blank should be the same as the volume of the samples with which it is shipped and it should be in the same type of container as the samples.

6.0 DOCUMENTATION

Comprehensive documentation of decontamination is accomplished by completion of the following:

6.1 Field Notebook Entries

- Date, time and location of each decontamination event
- Equipment decontaminated
- Solvents
- Notable circumstances
- Identification of field blanks and decontamination rinsates
- Method of blank and rinsate collection
- Date, time and location of blank and rinsate collection

6.2 Field Blank and Decontamination Rinsate Sample Labels

- Blanks and rinsates should be labeled as samples

6.3 Chain-of-Custody Forms

- Instructions for lab analyses of blanks and rinsates

7.0 REFERENCES

Not applicable.

ENSR

STANDARD OPERATING PROCEDURE

Number: 7720 **Date of Issue:** 2nd Qtr.1993

Revision: 1

Title: Rising-Head/Falling-Head Permeability Testing

Organizational Acceptance	Authorization	Date
Originator	Charles Martin	3/13/84
Technical Reviewer	Arthur Lazarus	3/13/84
Technical Reviewer	Elaine Moore	3/13/84
Technical Reviewer		
Quality Assurance	Scott Whittemore	3/13/84

Revision #	Changes	Authorization	Date
1	• Addition of Borehole Permeability Test Report form • Format update	Mike Dobrowolski	4/27/93

Organizational acceptance signatures are maintained on file with the original document in the Quality Assurance Library in Acton, MA.

ENSR ENSR Consulting and Engineering

Rising-Head/Falling-Head Permeability Testing

Date: 2nd Qtr. 1993
Revision No: 1
Author: Charles Martin
Discipline: Geosciences

1.0 PURPOSE AND APPLICABILITY

This SOP describes the procedures for conducting rising head and falling head permeability tests. Rising head/falling head tests are performed to determine the permeability of soil or rock within a test boring.

Falling head permeability tests are conducted in those boreholes that cannot be readily pumped or bailed for a rising head test. Two different methods for a falling head test may be used; one involves cleaning the casing completely to the bottom, the other involves back filling and pulling the casing above the bottom of the cleaned borehole.

2.0 RESPONSIBILITIES

2.1 It is the responsibility of the ENSR geologist or engineer to observe the performance of borehole permeability tests to ensure that all procedures are performed according to this SOP and to record any deviation from standard procedures along with rationale.

2.2 The geologist or engineer is also responsible for recording test data; and determining when tests will be performed, and duration of the test.

2.3 It is the responsibility of the contract driller to provide the necessary equipment.

3.0 REQUIRED MATERIALS

- Measuring tape with sounding device
- Stopwatch or other timing device
- Bucket
- Bailer
- Centrifugal pump

4.0 METHOD

4.1 General Procedure

4.1.1 Borings designated for permeability tests shall be selected prior to drilling. These holes shall be cased and the use of drilling mud or recirculated drill water will not be allowed as this will affect the permeability of the surrounding material.

4.1.2 Once the desired testing depth is reached, as determined by the project geologist/engineer, the drilling operations shall be stopped and the casing properly seated at the depth of the drilling bit. The casing shall then be cleaned to remove all loose materials and drill rods withdrawn slowly to prevent loosening of the soil at the bottom of the boring.

4.1.3 Top of casing shall be the reference datum for all measurements. Elevation difference between top of casing and ground surface shall be documented.

4.2 Rising-Head Test

4.2.1 Once the casing has been seated and cleaned, the water level shall be allowed to stabilize for 10 to 15 minutes prior to testing.

4.2.2 After stabilization, the water level is then temporarily lowered by bailing or with the use of a pump.

4.2.3 Recovery measurements are then taken at a pre-selected time interval using the measuring tape and recorded on the permeability-test form. Reference datum shall be top casing.

4.2.4 The test may be repeated if necessary.

4.3 Falling-Head Test (Flush Bottom)

4.3.1 Once the casing has been seated and cleaned, the hole is then filled with water to a level within 5 feet from the top of the casing. This water level is maintained for 10 to 15 minutes, by adding water if necessary, to allow for development of a steady seepage rate.

4.3.2 When the water level has been adjusted for the last time, the initial test water-level shall be recorded.

4.3.3 The timing device shall then be started.

4.3.4 Proceed to take drawdown measurements at the selected time interval using the measuring tape until stabilization is reached. Reference datum shall be top of casing.

4.3.5 Record all values onto the permeability test form.

4.3.6 Repeat the test if necessary.

4.4 Falling-Head Test (Pulled-back Casing)

4.4.1 Utilize the same procedure as in Section 4.3 except that the casing shall be backfilled with a clean, washed sand to a designated depth and the casing shall then be pulled back a designated amount.

4.4.2 Amount of backfill and length of pull-back will be determined by the geologist or engineer prior to testing.

4.5 Recorded Data

The following is a list of required data to be recorded on the Borehole Permeability Test Report (Figure 1):

- ground elevation
- reference elevation (top of casing)
- depth of test run
- casing diameter
- length of uncased borehole
- Equipment Identification

Other data to be recorded is listed on the included test report.

5.0 QUALITY CONTROL

Not applicable.

6.0 DOCUMENTATION

A permeability test report (Figure 1) shall be completed by the geologist or engineer for each test conducted.

All documentation shall be retained in the project files following completion of the project.

7.0 REFERENCES

Not applicable.

BOREHOLE PERMEABILITY TEST REPORT

SITE/LOCATION ______________________ BORING/PIEZ. NO. __________

CONTRACTOR ______________________ JOB NO. __________ TEST NO. __________

WELLPOINT ☐ STANDPIPE ☐ DATE __________ TEST DEPTH (A) __________

WATERTABLE DEPTH (D) __________ BORING DEPTH __________ CASING/STANDPIPE DIAM.(2r) __________

BORING DIAM. (2R) __________ WELLPOINT/UNCASED BORING LENGTH(L) __________

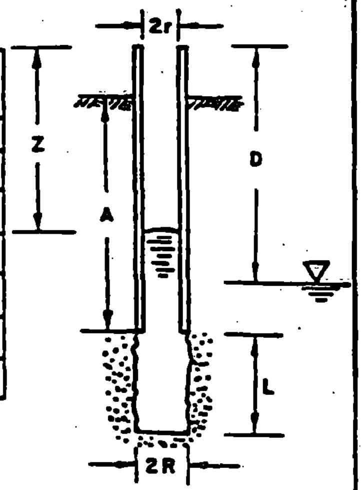
TYPE OF TEST: FALLING HEAD ☐ RISING HEAD ☐ CONSTANT FLOW ☐ FLOW METER NO. __________

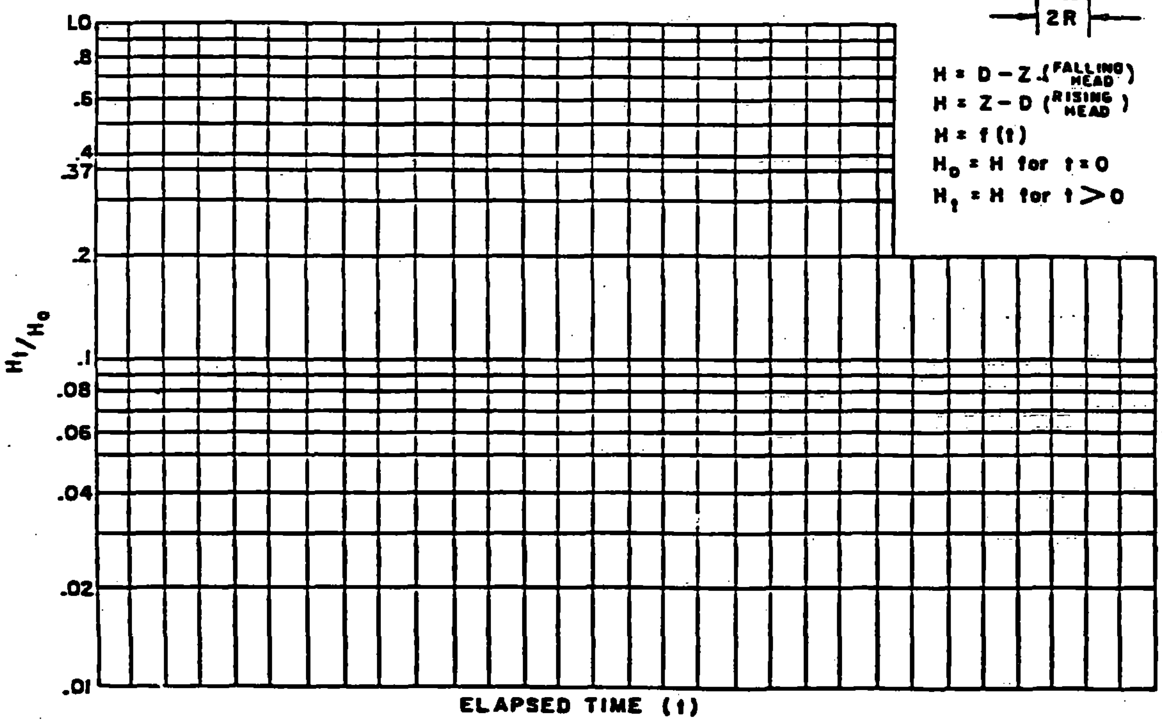
RIG & CREW TIME __________ GROUND ELEVATION __________ REFERENCE ELEVATION __________

TAPE/RULE NO. __________ INSPECTOR __________ CHEK'D BY __________

TIME	ELAPSED TIME (t)	GALLONS	WATER DEPTH (Z)	ACTIVE HEAD (H)	H_t/H_o
	0				1.0

VARIABLE HEAD TEST





$H = D - Z$ (FALLING HEAD)

$H = Z - D$ (RISING HEAD)

$H = f(t)$

$H_o = H$ for $t = 0$

$H_t = H$ for $t > 0$

COMMENTS:

UNO-VEN Refinery

Lemont, Illinois

ENSR

Supplemental Groundwater Investigation Report - RCRA Alternate Groundwater Monitoring Program for the Stormwater Basin

ENSR Consulting and Engineering

December 1993

Document Number 6941-006-734

UNO-VEN Refinery

Lemont, Illinois

Supplemental Groundwater Investigation Report - RCRA Alternate Groundwater Monitoring Program for the Stormwater Basin

ENSR Consulting and Engineering

December 1993

Document Number 6941-006-734

CONTENTS

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1.0 INTRODUCTION

This document presents the results of the supplemental groundwater investigation conducted as part of the Resource Conservation and Recovery Act (RCRA) Alternate Groundwater Monitoring Program in the stormwater basin (SWB) area at UNO-VEN's refinery in Lemont, Illinois (Figure 1-1). The objectives of the investigation were: (1) to evaluate the groundwater flow around the SWBs, particularly along the north side of the east basin, (2) to assess the impact of the SWB on the quality of groundwater directly adjacent to it, and (3) to identify fractures/voids in the bedrock and define the extent of the oily residue in bedrock immediately north of the east SWB.

1.1 Project Background

ENSR implemented the RCRA Alternate Groundwater Monitoring Program for the SWBs in September 1991. The program is being conducted according to the procedures described in the *Work Plan for a RCRA Alternate Groundwater Monitoring Program - Stormwater Basin* (ENSR Document No. 6941-006-470). The Work Plan was approved by the United States Environmental Protection Agency (U.S. EPA) subject to conditions outlined in a May 1992 letter to UNO-VEN. These conditions included installation of two clustered monitoring wells to evaluate shallow and deep groundwater quality on the north side of the east SWB.

From August 28 through 31, 1992, ENSR attempted to install the monitoring well cluster as directed by U.S. EPA. During drilling, however, a highly fractured or void zone was encountered; oily residue was observed floating on the groundwater surface in this zone. The monitoring well cluster was relocated to an area approximately 200 feet north of the basin and 90 feet east of piezometer P-9. Here shallow monitoring well SWB-7 and deep monitoring well SWB-6 were installed.

As a result of the discovery of the oily residue north of the east SWB, UNO-VEN initiated an investigative program to characterize hydrogeologic conditions adjacent to the north wall of the east SWB. During a meeting on November 5, 1992, UNO-VEN, ENSR, and U.S. EPA representatives discussed a proposed plan to evaluate this area through geophysical survey methods (such as ground-penetrating radar) and installation of a monitoring well. The *Supplemental Groundwater Investigation Work Plan - RCRA Alternate Groundwater Monitoring Program for the Stormwater Basin* (ENSR Document No. 6941-006-720) was prepared by ENSR based on the November 5 meeting; U.S. EPA approved the Work Plan on December 18, 1992.

1.2 Report Organization

This report provides a brief background of the supplemental groundwater investigation and describes the methods and results of the investigation. Section 1.0 is the introduction. Section 2.0 describes the methods used, and Section 3.0 presents the results of the investigation. ENSR's summary and conclusions are presented in Section 4.0. Section 5.0 contains references. Appendix A includes the boring log for monitoring well SWB-8, and Appendix B contains the hydraulic conductivity testing data.

2.0 SITE INVESTIGATION

The supplemental groundwater investigation conducted at the UNO-VEN Lemont refinery included the following tasks, conducted to characterize subsurface conditions:

- Ground-penetrating radar survey
- Monitoring well installation
- Hydraulic conductivity testing
- Water level monitoring
- Groundwater sampling

Each of these tasks is described in the following sections.

2.1 Ground-Penetrating Radar Survey

On January 19, 1993, ENSR conducted a ground-penetrating radar (GPR) survey north of the east SWB to define the extent of fractures/voids in the bedrock that have been associated with oily residues. A total of 3,180 linear feet of GPR data were acquired along 21 parallel lines, as shown on Figure 2-1. A GSSI SIR SYSTEM-3 coupled with a 500 MHz antenna was used to acquire continuous GPR data. Data were printed directly to an electrostatic printer (Model PR-8304).

Before conducting the full-scale survey, ENSR evaluated several different equipment setting combinations to determine the optimum recording settings for the GPR instrument. The settings used during the survey are listed in Table 2-1.

ENSR calibrated the GSSI at an area south of monitoring well SWB-2 (Figure 2-1) to establish a relative vertical scale and to determine the dielectric permittivity (ε_r) of the dolomite at the site. This calibration was performed by setting the instrument antenna on top of a rock ledge, then placing an object with a high potential for producing a reflection (an aluminum clipboard) beneath the ledge, approximately 8.5 feet below the antenna. A reflective event that directly corresponded to the placement of the clipboard was recorded at 55.2 nanoseconds. Based on this two-way travel time, the dielectric permittivity of the dolomite was calculated to be 10.5.

This value is slightly higher than published ε_r values for limestone, which are between 7 and 8 (Ulriksen, 1982). In general, the higher the ε_r value, the more the radar signal will be attenuated.

Two possible reasons for the slightly elevated ε_r value may be: (1) thin layers of weathered dolomite of higher ε_r within the bedding and fracture plane surfaces, and (2) moisture within the vugs in the dolomite. An increase from 0 to 1 percent in moisture content within a dolomite generally increases the ε_r value by 400 percent (Ulriksen, 1982).

GPR data were acquired in the vicinity of boring C-1 and monitoring well SWB-2 to determine how competent non-voided dolomite appeared on GPR records. The purpose of collecting these data was to establish the character (if any) of radar signals in the vicinity of the voids. It was expected that a strong reflective signal would be recorded from the roofs of the voids.

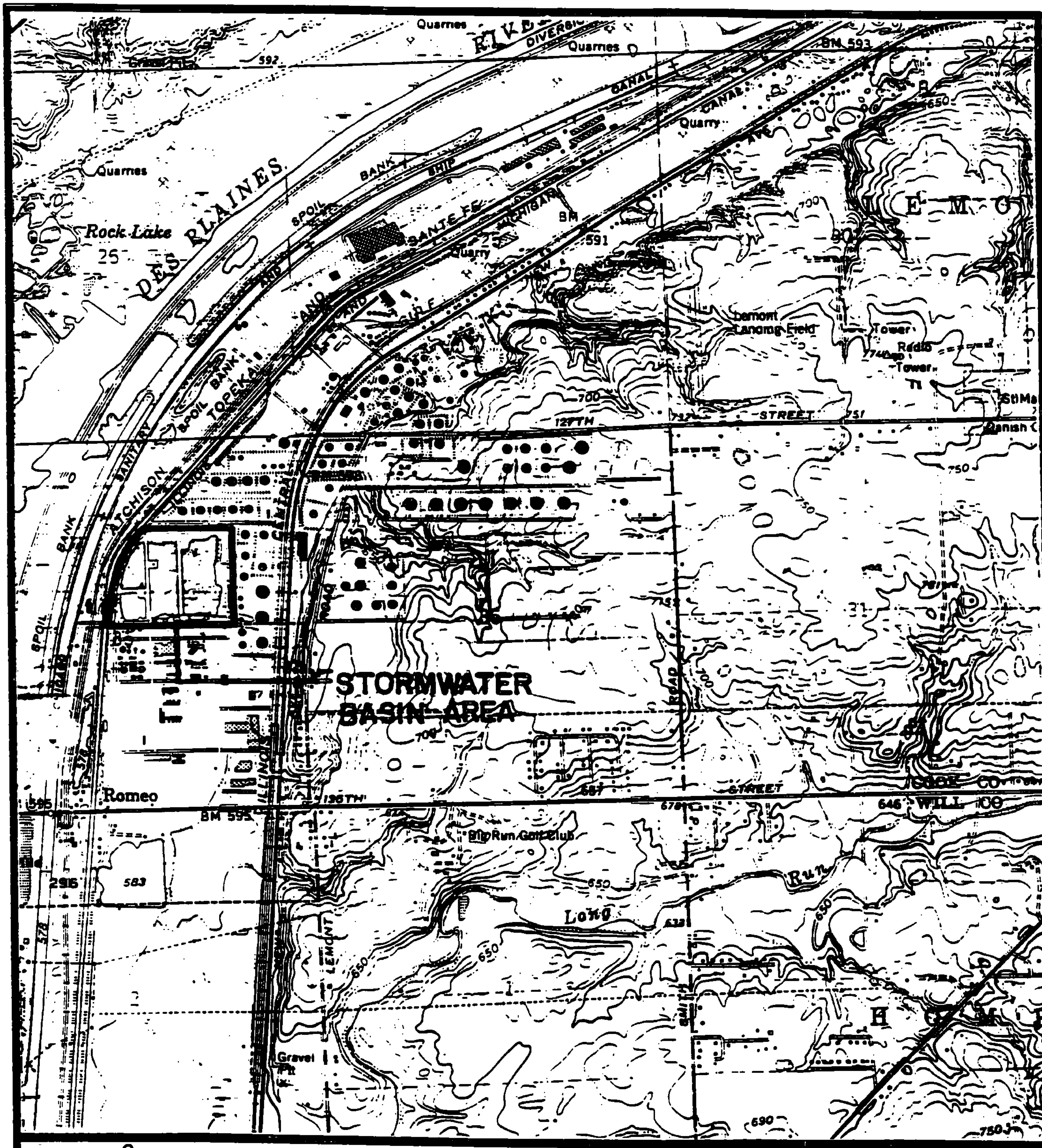
2.2 Monitoring Well Installation

On January 25, 1993, Fox Drilling, Inc., of Itasca, Illinois, began drilling monitoring well SWB-8 approximately 140 feet west of monitoring well SWB-2 and 30 feet north of the east SWB (Figure 2-2). The boring was advanced using 4¼-inch inside-diameter (ID) hollow-stem augers to a depth of approximately 3 feet. Beyond this depth, coring was performed in 8-foot runs using an NX-size core bit and barrel (with a borehole diameter of approximately 3 inches) to an approximate depth of 19 feet.

The dolomite was highly fractured and porous with some secondary vugs and weathering from approximately 3 to 11 feet. From approximately 11 to 19 feet, the dolomite became less fractured and more competent. The complete boring log for SWB-8 is presented in Appendix A. No void spaces were encountered; however, an oily sheen and petroleum odors were noted in several fractures. During coring, potable water was used to facilitate drilling.

One hour after the completion of coring activities, the water level within the borehole was measured at approximately 3.5 feet below ground surface. Because available water level measurements from surrounding wells ranged from 9 to 20 feet below ground surface, ENSR's geologist decided that the depth of the boring was adequate to install a well with a 10-foot screen that intersected the water table and that further drilling was not warranted. The borehole was enlarged using 6¼-inch ID hollow-stem augers to an approximate depth of 20 feet, and allowed to sit overnight to allow the water to seep in and the water level to stabilize. Measurements taken the following morning indicated a water level of approximately 7.7 feet below ground surface.

Based on the static water level, the borehole depth was adjusted to approximately 17 feet by filling the bottom of the borehole with 1 foot of sand then 2 feet of bentonite chips. Monitoring well SWB-8 was constructed using a 10-foot-long, 2-inch ID Type 304 stainless steel wire wrapped screen with 0.010-inch slots, and a flush-thread jointed 2-inch ID Type 304 stainless



0 1

SCALE IN MILES

Ref.: USGS Map, Romeoville, IL. Quadrangle, 1962, Photorevised 1973 and 1980.

N

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FIGURE 1–1

SITE LOCATION MAP

UNO–VEN REFINERY

LEMONT, ILLINOIS

DRAWN:	EDH	DATE:	8/12/91	PROJECT NUMBER:		REV.
APPV'D:		REVISED:	9/20/91	6941–006		1

steel riser. Well-sorted sand was installed by gravity around the borehole annulus to approximately 1 foot above the well screen. A 1-foot bentonite pellet seal was placed above the sand pack, and the remaining borehole annulus was filled with cement-bentonite grout. Completion of monitoring well SWB-8 included installation of a protective steel cover and a lock provided by UNO-VEN. Two 4-inch-diameter steel bumper posts were set in concrete around the well. Well construction details for SWB-8 are provided on the boring log in Appendix A.

The well was developed on February 5 and 10, 1993. On February 5, a Teflon bailer was used to surge the well in order to remove silt and clay particles from the filter pack around the screen and suspend them within the well water. The sediment-laden water was then removed using the bailer. The well was bailed dry several times with only partial recovery; a total of approximately 21 gallons were removed. Groundwater indicator parameters (pH, temperature, and specific conductivity) were measured for every well volume (1.5 to 2 gallons). Although stable readings were obtained during the development process, the clarity of the water was very poor; therefore, further development was necessary.

On February 10, 1993, ENSR again developed monitoring well SWB-8 using a bailer to remove fines. After bailing the well dry, ENSR used potable water from UNO-VEN's deep well to fill the well to the top of the well screen and repeat the surging process. Surging of the well continued until the water removed was essentially free of suspended sediment; a total of approximately 24 gallons of potable water was required to remove the fines from the well. Once the sediment was removed, water was introduced into the well and an additional 23 gallons were removed, while parameter measurements continued. A total of 15 well casing volumes were removed during monitoring well development, and at least three stable parameter measurements were obtained.

2.3 Hydraulic Conductivity Testing

From February 23 to April 23, 1993, ENSR conducted hydraulic conductivity testing of the dolomite bedrock at monitoring wells SWB-4, SWB-6, SWB-7, and SWB-8, and piezometers P-5 and P-13 (Figure 2-2) to determine the hydraulic conductivity of the upper fractures and the lower competent rock. The tests were also conducted to evaluate the groundwater velocity in the area north of the east SWB and estimate the rate of migration of potential contaminants between this area and the basin. The results of this testing and of packer and hydraulic conductivity testing results obtained during previous ENSR investigations (ENSR Document Nos. 6941-006-330 and 6941-006-450) are discussed in Section 3.2.

Hydraulic conductivity testing consisted of rising and/or falling head tests. In monitoring wells SWB-7 and SWB-8, testing was conducted by displacing groundwater in the wells using 1⅛-inch-outside-diameter (OD) stainless steel slugs measuring 2 feet and 4 feet, respectively. For monitoring wells SWB-4 and SWB-6, rising head tests were performed without a slug by evacuating all of the water from the well using a Keck SP-84™ submersible pump. Approximately 5.6 gallons of water were pumped from monitoring well SWB-4; approximately 2.7 gallons were pumped from well SWB-6. Falling head tests were completed for the piezometers by adding 0.44 gallons of distilled water to piezometer P-5 and 1.42 gallons to piezometer P-13.

Prior to hydraulic conductivity testing at each monitoring well or piezometer, ENSR obtained a reference static water level measurement and recorded the value in a field notebook. During testing, measurements of time/drawdown were collected using an in-situ data logging system consisting of a Model PTX1610 20 pounds per square inch gauge (psig) pressure transducer coupled with a Hermit™ Model SE1000C data logger. Upon completion of each test, ENSR downloaded the data to an IBM-compatible computer for analysis. Calculations of hydraulic conductivity were then made using the Hvorslev Method (Hvorslev, 1951) with Lotus 123™ and Grapher™ software. Section 3.2 presents the results of the hydraulic conductivity testing.

2.4 Water Level Monitoring

ENSR obtained monthly water level measurements during January through November 1993 from stormwater basin monitoring wells (SWB-1 through SWB-7); piezometers (P-1 through P-13); and staff gauges in the Illinois and Michigan (I&M) Canal, northwest SWB, treated water basin (TWB), and green coke storage area (GCSA) (Figure 2-2). The water level measurements collected were used to determine the hydrologic relationship of the SWBs and adjacent surface water bodies (I&M Canal) to the underlying bedrock aquifer in the vicinity of the basins.

Water level measurements were obtained from UNO-VEN's groundwater monitoring system using a Solinist™ electronic water level indicator, which provides a measurement of the water level to within $\pm$ 0.01 feet. Section 3.3 presents the results of the water level monitoring program conducted for the supplemental groundwater investigation and additional water level data from previous ENSR investigations beginning in June 1991 (ENSR Document Nos. 6941-006-330 and 6941-006-450).

2.5 Groundwater Sampling

ENSR collected groundwater samples from existing on-site monitoring wells (SWB-1 through SWB-7) and newly installed monitoring well SWB-8 during three separate sampling events (January, June, and September 1993) for the RCRA Alternate Groundwater Monitoring Program.

Prior to the collection of groundwater samples, each monitoring well was purged of at least three well casing volumes of water (or purged dry) to remove stagnant water from the well. Purging was conducted using either a decontaminated stainless steel or Teflon bailer. During purging, ENSR obtained measurements of pH, temperature, and specific conductance to determine whether stagnant water was replaced by groundwater representative of the formation surrounding the screen and gravel pack.

Following purging, a groundwater sample was collected from each monitoring well using a decontaminated stainless steel or Teflon bailer. Upon retrieval of the bailer from the screened interval of the well, the groundwater sample was transferred to the appropriate sample container by pouring the water from the top of the bailer.

During the January sampling event, groundwater samples were analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and groundwater indicator parameters (pH, specific conductance, total organic compounds [TOC], and total organic halogen [TOX]). In June, groundwater samples were analyzed only for VOCs and SVOCs. During the September event, samples were analyzed for VOCs, SVOCs, groundwater indicator parameters, and groundwater quality parameters (chloride, iron, manganese, phenols, sodium, and sulfate). A summary of the parameters for each sampling event is provided in Table 2-2.

For quality assurance purposes, field blanks and duplicates were collected during each sampling event and analyzed for the same parameters as the samples. A trip blank was also submitted with each shipment of VOC samples. The trip blank was analyzed for VOCs.

Sample containers were packaged and prepared for shipment to the analytical laboratory with chain-of-custody forms that included pertinent sampling information. Samples were shipped to AnalytiKEM Laboratories in Houston, Texas, and Rock Hill, South Carolina, via overnight courier and analyzed for the parameters listed in Table 2-2. The results of groundwater sample analyses are discussed in Section 3.4.

TABLE 2-1

Recording Settings on the GSSI SIR System-3

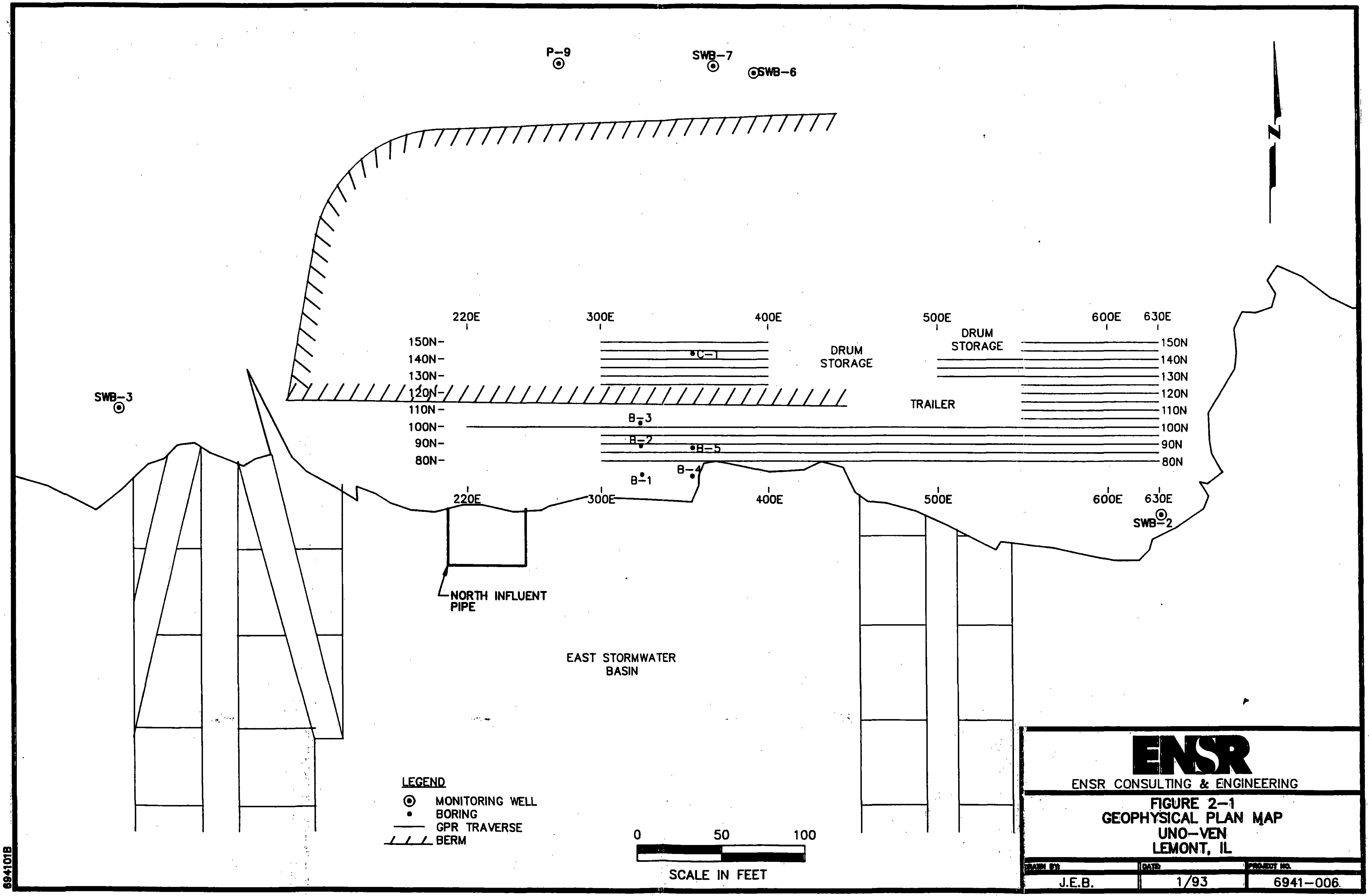
Paper speed	200 lines/inch
Scans per second	8
Surface grain	45%
Middle gain	50%
Deep gain	55%
Time sweep	120 nanoseconds
Hi-pass filter	10 cycles/scan
Lo-pass filter	50 cycles/scan
Transmit rate	50kHz

TABLE 2-2

Summary of the RCRA Groundwater Sampling Parameters
Stormwater Basin Monitoring Wells
January through September 1993

Parameters	January 6, 1993	June 29, 1993	September 24, 1993
Volatile organic compounds	✓	✓	✓
Semivolatile organic compounds	✓	✓	✓
pH[1]	✓		✓
Specific Conductance[1]	✓		✓
Total organic carbon (TOC)	✓		✓
Total organic halogen (TOX)	✓		✓
Chloride			✓
Iron			✓
Manganese			✓
Phenols			✓
Sulfate			✓
Sodium			✓

[1]Field measurement.



P-9
SWB-7
SWB-6
SWB-3
SWB-2
N
220E
300E
400E
500E
600E
630E
150N
140N
130N
120N
110N
100N
90N
80N
C-1
B-1
B-2
B-3
B-4
B-5
DRUM STORAGE
DRUM STORAGE
TRAILER
NORTH INFLUENT PIPE
EAST STORMWATER BASIN
LEGEND
MONITORING WELL
BORING
GPR TRAVERSE
BERM
0
50
100
SCALE IN FEET
ENSR
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FIGURE 2-1
GEOPHYSICAL PLAN MAP
UNO-VEN
LEMONT, IL
J.E.B.
1/93
6941-006
694101B

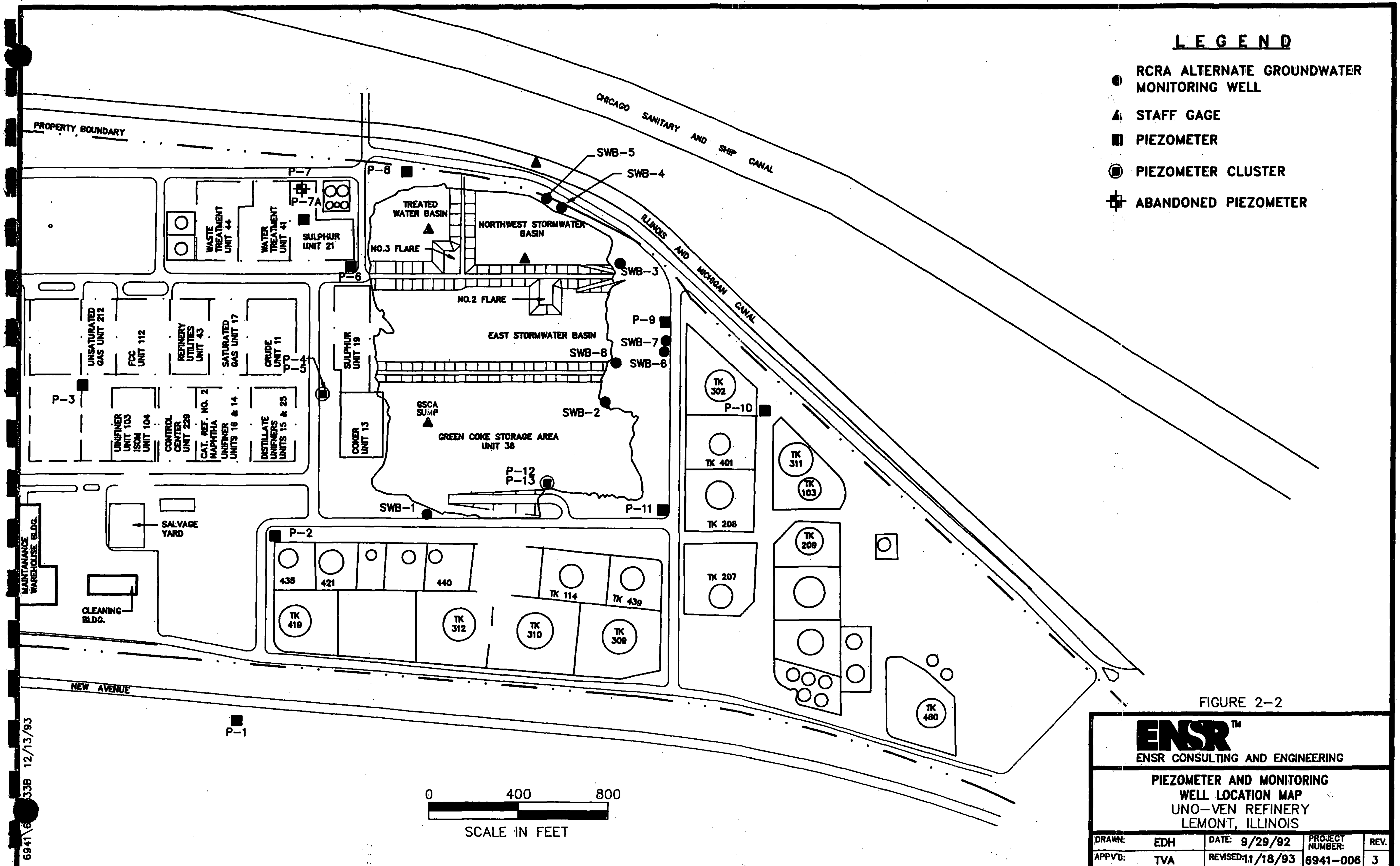

FIGURE 2-2

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PIEZOMETER AND MONITORING WELL LOCATION MAP
UNO-VEN REFINERY
LEMONT, ILLINOIS

DRAWN:	EDH	DATE: 9/29/92	PROJECT NUMBER:	REV.
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3.0 INVESTIGATION RESULTS

This section presents the results of the supplemental groundwater investigation conducted by ENSR from January 1 through November 30, 1993, and also includes data (water level measurements and hydraulic conductivity testing results) from previous investigations conducted by ENSR at the UNO-VEN facility. Section 3.1 discusses the results of the GPR survey along the north edge of the east SWB. Hydraulic conductivity testing results and water level measurements are presented in Sections 3.2 and 3.3, respectively. Section 3.4 provides the groundwater quality results from sampling events conducted in January, June, and September 1993.

3.1 Fractured Bedrock Delineation

The GPR signal character in the vicinity of monitoring well SWB-2 revealed multiple horizontal reflections from 42 to 75 nanoseconds (approximately 6 to 12 feet below ground surface). These reflections, most likely caused by the horizontal bedding of the dolomite, are labeled A on Figure 3-1. Multiple horizontal reflections were also present along line 95 north from stations 485 east to 500 east (labeled B in Figure 3-1). It appears that the area labeled B on Figure 3-1 also represents competent bedrock.

Multiple horizontal reflections similar to those labeled A and B in Figure 3-1 were also detected between stations 320 east to 350 east along line 95 north (labeled C in Figure 3-1). This location is coincident with borings B-1 through B-5, where voids were encountered at 10.5 to 14 feet below ground surface. The reflective event that was expected at the roof of a void (at a depth of 10.5 feet) was not observed. One explanation for the signals that were recorded may be the 18 cubic yards of grout pumped into the boreholes upon their completion.

On most of the GPR records, these multiple horizontal reflections are absent. This may be due to a slight increase in the rock moisture content, which would prevent reflections, or it may indicate a more weathered rock. It should be noted that the absence of multiple horizontal reflections does not necessarily indicate that bedrock is weathered or voided at depth; it just indicates that conditions were not suitable for reflections.

Based on these results, a boring located along line 95 north, at station 490 east, was expected to encounter competent rock. This location is shown as a boxed-in circle in Figure 3-2; Figure

3-2 also shows the expected areal extent of competent bedrock based on the character of GPR signals.

3.2 Bedrock Hydraulic Conductivity

The hydraulic conductivity data collected between February and April 1993 were analyzed using the Hvorslev Method (Hvorslev, 1951). Using this method, the ratio H/Ho is plotted against the time on a semilogarithmic graph. The value Ho corresponds to the initial water column added or displaced; H is the height of the water column above or below the static water level as recorded during the test. The semilogarithmic plots of H/Ho versus time for monitoring wells SWB-4, SWB-6, SWB-7, and SWB-8, and piezometers P-5 and P-13 are shown in Figures 3-3 through 3-8. The hydraulic conductivity test data obtained from the Hermit™ data logger are provided in Appendix B.

The hydraulic conductivity (K) of the dolomite bedrock around the well screen can be calculated from the following equation (Hvorslev, 1951):

$$K = A/FT$$

Where: A = cross sectional area of riser
F = shape factor
T = basic time lag

For wells screened in water-bearing formations under unconfined conditions, the ratio of the cross sectional area to the shape factor is given by:

$$A/F = d^2 \; x \; \ln \; [L/D + \sqrt{1 + (L/D)^2}\,]/8L$$

Where: d = riser (casing) diameter
ln = natural log
D = borehole diameter
L = length of water intake or screen

The basic time lag (T) can be calculated from the semilogarithmic plot of H/Ho versus time. The interception of the best fit line through both test data and the H/Ho value at 0.37 would be used to determine the T. All other parameters needed for calculating the hydraulic conductivity are obtained from the construction of each monitoring well. Table 3-1 lists the hydraulic conductivities calculated by the Hvorslev Method and the parameters used in the calculations. This table shows that the highest hydraulic conductivity (3.5×10^{-3} cm/sec) was obtained in shallow monitoring well SWB-8 and the lowest (4.8×10^{-9} cm/sec) was measured in deep well SWB-6.

The hydraulic conductivity values obtained during this study and previous studies at the UNO-VEN refinery are summarized in Table 3-2. For the shallow monitoring wells and piezometers with screen intervals extending from 8 to 28 feet, the calculated hydraulic conductivities varied from 5.7×10^{-3} to 1.4×10^{-5} cm/sec. For the deep monitoring wells and piezometers with screen intervals extending from 43 to 50 feet, the calculated hydraulic conductivities varied from 2.4×10^{-5} to 4.8×10^{-9} cm/sec. The difference in the hydraulic conductivity values between the upper 20 to 30 feet of dolomite bedrock and the lower 40 to 50 feet confirms the presence of the weathered and fractured rock observed in the upper zone during drilling and coring compared to the competent rock observed in the lower zone.

3.3 Groundwater Elevation and Flow

Since June 1991, water level data have been collected from the SWB monitoring wells, piezometers, and staff gauges every month (except in August 1991, July 1992, August 1992, and October 1992). Complete water level measurement data, including water level elevations, are summarized in Table 3-3. Hydrographs of the water level elevations, versus time or date of measurement are provided in Figures 3-9 through 3-16. These figures show that over the 2½-year period that water levels were collected, the levels in the northwest SWB slightly exceeded the water levels in the Illinois and Michigan (I&M) Canal only twice: on November 4, 1991, and on January 6, 1993. All other water level measurements in the I&M Canal were between 2 and 5 feet higher than the levels in the northwest SWB. The hydrographs also show that on November 4, 1991, and January 6, 1993, the water level in the northwest basin reached a high-water stage caused by heavy precipitation and surface water runoff.

Similarly, with the exception of November 4, 1991, and January 6, 1993, the water levels in shallow monitoring well SWB-5 (located between the northwest SWB and the I&M Canal) were consistently higher than the levels in the SWB (Figure 3-10). This clearly indicates an inward groundwater flow into the basin along its western section. Water levels in deep monitoring well SWB-4, which are usually higher than those in shallow well SWB-5 (Figure 3-10), also indicate an upward groundwater flow component toward the basin. Water levels in shallow and deep monitoring wells SWB-5 and SWB-4 closely follow the water level fluctuation in the northwest SWB.

The water level in monitoring well SWB-3, located just north of the northwest SWB, was generally higher than the level in the basin by less than 0.2 feet (Table 3-3). Occasionally the water level in SWB-3 dropped below the level in the basin by less than 0.2 feet. This variance may indicate a change in flow direction with fluctuation of the water level in the basin. While groundwater along the north portion of the northwest SWB generally flows toward the basin, on occasion groundwater may reverse direction and flow outward from the basin. Figure 3-9 clearly demonstrates how closely the water level in monitoring well SWB-3 follows the level in the SWB.

The water levels in monitoring wells SWB-8 (adjacent to the northeast corner of the east SWB) and SWB-7 and in piezometer P-9 (located approximately 250 feet north of the east SWB) are clearly higher than the levels in the SWB (Table 3-3). In deep monitoring well SWB-6, the water level never reached equilibrium (static) conditions between sampling events because of the extremely low hydraulic conductivity of the bedrock in which the well is screened. The water level in monitoring well SWB-8 is approximately 3 feet higher than the level in the east SWB. The levels in monitoring well SWB-7 and piezometer P-9 are also between 3 and 5 feet higher than the levels in the east SWB. This significant head difference between the east SWB and the wells north of the basin (Figures 3-11 and 3-15) clearly indicates a constant inward groundwater flow toward the basin from the north. These figures also demonstrate that the water levels in monitoring wells SWB-8 and SWB-7 and in piezometer P-9 mirror the water level fluctuation in the basin.

The groundwater velocity or seepage velocity (v) from the area north of the east SWB toward the basin can be calculated from Darcy's Law:

$$v = \frac{Ki}{n}$$

Where: K = hydraulic conductivity
i = hydraulic gradient
n = effective porosity

The hydraulic conductivity for the area north of the east SWB is calculated at 2.4×10^{-3} cm/sec (6.9 ft/year) based on the average hydraulic conductivity in monitoring wells SWB-7 and SWB-8 and piezometer P-9 (Table 3-2). The average hydraulic gradient between monitoring well SWB-7 and piezometer P-9, monitoring well SWB-8, and the east SWB is calculated at 0.02 ft/ft, based on the water level data and the distances between the measuring points. The effective porosity of the upper fractured dolomite is assumed to be 0.15 (Todd, 1980).

The calculated groundwater velocity toward the east SWB from the area north of the basin is approximately 0.9 ft/day or 330 ft/year. This indicates that a contaminant detected at monitoring well SWB-7 would reach the east SWB within approximately 9 months, assuming no attenuation. In reality, however, the contaminants would migrate at a somewhat slower rate than the groundwater velocity because of adsorption of the contaminants onto the rock matrix.

The water table elevation contour maps generated from data collected on January 6, 1993; June 28, 1993; and September 22, 1993, are presented in Figures 3-17, 3-18, and 3-19, respectively. Water level measurements from monitoring wells SWB-4 and SWB-6 and piezometers P-1, P-5, and P-13 were not included because these wells and piezometers are screened at depths greater than 20 feet below the water table.

The water table maps clearly indicate a radial groundwater flow into the SWBs and the GCSA sump. The basins and, in particular, the GCSA sump act as local sink or discharge areas; groundwater is discharging into the SWBs and the sump from areas to the north, south, east, and west. On only one occasion (January 6, 1993--see Figure 3-17), during a high water stage in the basin, an outward flow along the west portion of the northwest SWB toward the I&M Canal was detected.

Surface water from the TWB is also migrating toward the SWBs; water from the SWBs is seeping into the GCSA sump.

3.4 Groundwater Quality

Groundwater samples were collected every quarter from all SWB monitoring wells (SWB-1 through SWB-8). The samples were analyzed each quarter for VOCs and SVOCs. The results for the January 6, 1993; June 29, 1993; and September 24, 1993, sampling events are presented, with complete laboratory analytical data, in the quarterly groundwater monitoring reports. Table 3-4 presents a summary of the VOC analytical results for the three quarterly sampling events. A summary of the SVOC analytical results for the three quarters is provided in Table 3-5.

Table 3-4 indicates that benzene, toluene, ethylbenzene, and xylene (BTEX) were detected in all monitoring wells except SWB-3, SWB-4, and SWB-5. BTEX compounds were detected at the highest concentrations in monitoring well SWB-8, where benzene concentrations ranged from 3,200 to 6,000 μg/l. Benzene was also detected in monitoring well SWB-7 at relatively high concentrations (620 to 730 μg/l). Moderate benzene concentrations (between 30 and 76 μg/l) were detected in monitoring wells SWB-1 and SWB-2.

Benzene concentration contours for the January, June, and September events are presented in Figures 3-20, 3-21, and 3-22, respectively. These figures demonstrate that the benzene contaminant plume is centered around monitoring well SWB-8 at the northeast corner of the east SWB. The source of the benzene contamination has not yet been defined. However, based on past operations at the site and the direction of groundwater flow, it is assumed that the sludge drying beds or surrounding areas are contributing to the benzene plume. This assumption will be tested during the proposed characterization of the sludge drying bed area that will be conducted as part of the SWB closure.

Several SVOCs were detected in the monitoring wells (Table 3-5); most in wells SWB-7 and SWB-8. Except for di-n-butylphthalate (in SWB-4 and SWB-5), no SVOCs were present in monitoring wells SWB-1, SWB-3, SWB-4, and SWB-5; di-n-butylphthalate is a common laboratory artifact. Phenol was detected in monitoring well SWB-7 during the January and September sampling events at concentrations of 4,600 and 5,200 $\mu g/l$, respectively; phenol was not detected during the second quarter (June) sampling event. Phenol was detected (at 200 $\mu g/l$) in monitoring well SWB-8 only during the third quarter (September) sampling event.

Other SVOCs were detected in monitoring wells SWB-7 and SWB-8. Naphthalene and 2-methylnaphthalene were detected in monitoring well SWB-7 only during the June sampling event, but were detected in well SWB-8 during each of the three sampling events. 2-Methylphenol and 3+4-methylphenol were detected in monitoring wells SWB-7 and SWB-8 in September only. 4-Methylphenol was detected in monitoring well SWB-8 only during the June sampling.

Five SVOCs were detected in monitoring well SWB-6. Three of these compounds (2,4-dimethylphenol, 2,4-dichlorophenol, and 2,4,5-trichlorophenol) were detected during the June sampling event; the other two compounds (2,4,6-trichlorophenol and di-n-butylphthalate) were detected during the September sampling event. Only one SVOC (2-methylnaphthalene) was detected in monitoring well SWB-2 during the June and September sampling events.

Based on past operations at the site and the direction of the groundwater flow, the source of the SVOC constituents in the stormwater basin monitoring wells, particularly in SWB-7 and SWB-8, is likely the sludge drying bed area or the tank farm northeast of the sludge drying beds. The site characterization of the area north of the east basin will better define the source of the groundwater constituents detected during the supplemental groundwater investigation.

TABLE 3-1

Calculated Hydraulic Conductivities

Well No.	Riser Diameter (in)	Borehole Diameter (in)	Water Intake (ft)	Lag Falling (min)	Basic Time Rising (min)	Conductivity Falling (cm/sec)	Hydraulic Rising (cm/sec)
SWB-4	2	6	5	--	399	--	2.65×10^{-6}
SWB-6	2	10	5	--	183,960	--	4.7×10^{-9}
SWB-7	2	10	10	31	55	1.81×10^{-5}	1.02×10^{-5}
SWB-8	2	10	9	--	0.17	--	3.54×10^{-3}
P-5	1	3	5	13.7	--	2.38×10^{-5}	--
P-13	1	3	5	2,849	--	1.14×10^{-7}	--

Note: The level of the water intake corresponds to the length of the screen in wells where the static water level is above the screen. In wells where the static water level is below the top of the screen, the length corresponds to the length between the static water level and the bottom of the screen.

$$K = A/FT = d^2 \times \ln\left[L/D + \sqrt{(1 + (L/D)^2)}\right]/8L$$

Where:
K = Isotropic hydraulic conductivity
A = Cross-sectional area of standpipe
F = Shape factor
T = Basic time lag
d - Riser diameter
D = Borehole diameter
L = Length of water intake

TABLE 3-2

Summary of Hydraulic Conductivity Test Results

Well Number	Screen Interval (feet)[1]	Hydraulic Conductivity (cm/sec)
SWB-1[2]	14 - 24	3.9×10^{-4}
SWB-2[2]	15 - 25	1.4×10^{-5}
SWB-3[2]	8 - 18	2.8×10^{-3}
SWB-4[3]	44 - 49	2.7×10^{-6}
SWB-5[2]	8 - 18	1.0×10^{-4}
SWB-6[3]	45 - 50	4.8×10^{-9}
SWB-7[3]	10 - 20	1.4×10^{-5}
SWB-8[3]	7 - 17	3.5×10^{-3}
P-1	28 - 39	No test
P-2[4]	11 - 21	2.7×10^{-5}
P-3[4]	12 - 22	1.5×10^{-4}
P-4[4]	12 - 22	2.6×10^{-5}
P-5[3]	45 - 50	2.4×10^{-5}
P-6[4]	7 - 17	4.4×10^{-5}
P-7[4]	11 - 21	3.1×10^{-5}
P-8[4]	12 - 22	5.7×10^{-3}
P-9[4]	8 - 18	3.8×10^{-3}
P-10[4]	12 - 22	8.7×10^{-4}
P-11[4]	13 - 23	6.0×10^{-4}
P-12[4]	18 - 28	1.6×10^{-4}
P-13[3]	43 - 48	1.1×10^{-7}

[1]Measured from ground surface.
[2]Slug test (ENSR, February 1991).
[3]Present study.
[4]Pressure (packer) test (ENSR, September 1991).

TABLE 3-3

SUMMARY OF WATER LEVEL ELEVATIONS (ft. MSL) IN THE VICINITY OF THE SWB

			6/25/91		7/30/91		9/13/91		10/3/91		11/4/91		12/11/91	
Monitoring Well	Screen Interval	TOR Elevation	Depth to Water	Water Level Elevation	Depth to Water	Water Level Elevation	Depth to Water	Water Level Elevation	Depth to Water	Water Level Elevation	Depth to Water	Water Level Elevation	Depth to Water	Water Level Elevation
SWB-1	16-26	592.43	18.74	573.69	19.47	572.96	18.26	574.17	18.39	574.04	19.83	572.60	19.60	572.83
SWB-2	17-27	588.90	20.80	568.10	21.25	567.65	20.43	568.47	20.59	568.31	19.86	569.04	19.75	569.15
SWB-3	10-20	588.53	14.45	574.08	13.99	574.54	12.65	575.88	13.30	575.23	9.52	579.01	13.20	575.33
SWB-4	46-51	589.73	15.30	574.43	15.27	574.46	14.54	575.19	14.90	574.83	10.67	579.06	14.39	575.34
SWB-5	10-20	589.97	15.78	574.19	13.45	576.52	14.00	575.97	14.60	575.37	11.00	578.97	14.63	575.34
SWB-6	48-53	589.28	--	--	--	--	--	--	--	--	--	--	--	--
SWB-7	12-22	589.14	--	--	--	--	--	--	--	--	--	--	--	--
SWB-8	9-19	588.95	--	--	--	--	--	--	--	--	--	--	--	--
Piezometer														
P-1	30-40	598.35	12.87	585.48	13.48	584.87	13.48	584.87	13.43	584.92	12.04	586.31	11.02	587.33
P-2	13-23	593.36	7.25	586.11	8.02	585.34	7.48	585.88	7.55	585.81	6.17	587.19	6.03	587.33
P-3	14-24	593.23	6.13	587.10	6.93	586.30	7.01	586.22	7.00	586.23	5.67	587.56	5.37	587.86
P-4	14-24	592.96	9.50	583.46	10.44	582.52	10.81	582.15	10.80	582.16	9.13	583.83	8.53	584.43
P-5	47-52	593.10	9.50	583.60	10.24	582.86	10.50	582.60	10.45	582.65	9.02	584.08	8.39	584.71
P-6	10-20	594.18	12.14	582.04	12.66	581.52	11.78	582.40	12.31	581.87	10.22	583.96	11.10	583.08
P-7	13-23	592.87	8.49	584.38	8.32	584.55	7.82	585.05	8.90	583.97	7.75	585.12	6.92	585.95
P-7A	12-22	592.68	--	--	--	--	--	--	--	--	--	--	--	--
P-8	15-25	592.68	9.80	582.88	10.50	582.18	9.20	583.48	9.87	582.81	10.13	582.55	10.27	582.41
P-9	11-21	589.95	11.74	578.21	13.29	576.66	11.97	577.98	12.32	577.63	8.25	581.70	9.74	580.21
P-10	14-24	588.98	9.35	579.63	11.13	577.85	7.83	581.15	8.37	580.61	6.08	582.90	6.93	582.05
P-11	15-25	592.72	12.35	580.37	12.86	579.86	12.82	579.90	12.84	579.88	11.91	580.81	11.40	581.32
P-12	20-30	591.01	20.72	570.29	20.85	570.16	20.97	570.04	21.04	569.97	20.73	570.28	20.42	570.59
P-13	45-50	590.82	25.58	565.24	26.13	564.69	26.45	564.37	25.88	564.94	25.68	565.14	24.35	566.47
Staff Gauge														
I&M Canal		586.12	1.60	577.72	1.40	577.52	1.67	577.79	1.70	577.82	2.20	578.32	2.10	578.22
NW SWB		576.25	7.83	574.08	8.10	574.35	9.60	575.85	9.00	575.25	12.75	579.00	9.10	575.35
TWB		587.98	9.40	583.38	8.00	581.98	10.40	584.38	9.50	583.48	--	--	8.20	582.18
GCSA		569.72	--	--	--	--	--	--	--	--	--	--	--	--

TABLE 3-3

SUMMARY OF WATER LEVEL ELEVATIONS (ft. MSL) IN THE VICINITY OF THE SWB

Monitoring Well	Screen Interval	TOR Elevation	1/3/92 Depth to Water	1/3/92 Water Level Elevation	2/7/92 Depth to Water	2/7/92 Water Level Elevation	3/6/92 Depth to Water	3/6/92 Water Level Elevation	4/3/92 Depth to Water	4/3/92 Water Level Elevation	5/1/92 Depth to Water	5/1/92 Water Level Elevation	6/12/92 Depth to Water	6/12/92 Water Level Elevation
SWB-1	16-26	592.43	20.25	572.18	20.30	572.13	20.32	572.11	20.60	571.83	20.33	572.10	18.59	573.84
SWB-2	17-27	588.90	20.55	568.35	20.75	568.15	20.44	568.46	20.90	568.00	20.64	568.26	21.23	567.67
SWB-3	10-20	588.53	13.08	575.45	13.38	575.15	14.42	574.11	15.48	573.05	15.25	573.28	15.89	572.64
SWB-4	46-51	589.73	14.15	575.58	14.35	575.38	15.40	574.33	16.29	573.44	16.30	573.43	16.79	572.94
SWB-5	10-20	589.97	14.45	575.52	14.74	575.23	15.72	574.25	16.67	573.30	16.57	573.40	17.17	572.80
SWB-6	48-53	589.28	--	--	--	--	--	--	--	--	--	--	--	--
SWB-7	12-22	589.14	--	--	--	--	--	--	--	--	--	--	--	--
SWB-8	9-19	588.95	--	--	--	--	--	--	--	--	--	--	--	--
Piezometer														
P-1	30-40	598.35	11.65	586.70	11.65	586.70	11.55	586.80	11.40	586.95	11.20	587.15	10.95	587.40
P-2	13-23	593.36	6.80	586.56	6.81	586.55	10.40	582.96	10.25	583.11	9.98	583.38	7.82	585.54
P-3	14-24	593.23	5.91	587.32	6.01	587.22	6.57	586.66	6.15	587.08	6.14	587.09	6.40	586.83
P-4	14-24	592.96	8.90	584.06	9.31	583.65	9.63	583.33	9.91	583.05	9.72	583.24	10.55	582.41
P-5	47-52	593.10	8.79	584.31	9.11	583.99	9.93	583.17	10.15	582.95	10.01	583.09	10.35	582.75
P-6	10-20	594.18	11.30	582.88	11.15	583.03	11.02	583.16	11.22	582.96	11.01	583.17	11.60	582.58
P-7	13-23	592.87	6.88	585.99	6.92	585.95	7.08	585.79	7.63	585.24	7.64	585.23	7.70	585.17
P-7A	12-22	592.68	--	--	--	--	--	--	--	--	--	--	--	--
P-8	15-25	592.68	10.31	582.37	10.12	582.56	10.08	582.60	10.24	582.44	10.03	582.65	8.52	584.16
P-9	11-21	589.95	11.03	578.92	11.41	578.54	11.30	578.65	11.70	578.25	10.86	579.09	11.82	578.13
P-10	14-24	588.98	8.14	580.84	8.75	580.23	8.38	580.60	8.65	580.33	7.98	581.00	9.82	579.16
P-11	15-25	592.72	11.64	581.08	12.00	580.72	11.74	580.98	11.75	580.97	12.03	580.69	12.73	579.99
P-12	20-30	591.01	20.63	570.38	23.62	567.39	23.42	567.59	25.60	565.41	25.30	565.71	26.00	565.01
P-13	45-50	590.82	25.60	565.22	25.40	565.42	25.20	565.62	27.62	563.20	27.44	563.38	27.81	563.01
Staff Gauge														
I&M Canal		586.12	1.78	577.90	1.87	577.99	1.82	577.94	1.88	578.00	1.86	577.98	1.55	577.67
NW SWB		576.25	9.25	575.50	8.85	575.10	7.80	574.05	7.00	573.25	7.00	573.25	6.60	572.85
TWB		587.98	8.40	582.38	8.55	582.53	8.50	582.48	8.40	582.38	8.80	582.78	11.60	585.58
GCSA		569.72	--	--	6.31	563.41	10.83	558.89	13.08	556.64	8.42	561.30	7.48	562.24

TABLE 3-3

SUMMARY OF WATER LEVEL ELEVATIONS (ft. MSL) IN THE VICINITY OF THE SWB

			9/23/92		11/10/92		12/21/92		01/06/93		02/19/93		03/26/93	
Monitoring Well	Screen Interval	TOR Elevation	Depth to Water	Water Level Elevation	Depth to Water	Water Level Elevation	Depth to Water	Water Level Elevation	Depth to Water	Water Level Elevation	Depth to Water	Water Level Elevation	Depth to Water	Water Level Elevation
SWB-1	16-26	592.43	18.68	573.75	18.91	573.52	19.65	572.78	19.03	573.41	20.45	571.98	19.25	573.18
SWB-2	17-27	588.90	19.83	569.07	20.20	568.70	20.83	568.07	19.02	569.88	20.09	568.81	19.85	569.05
SWB-3	10-20	588.53	13.80	574.73	13.86	574.67	13.66	574.87	8.89	579.64	14.27	574.26	11.25	577.28
SWB-4	46-51	589.73	14.85	574.88	14.82	574.91	14.75	574.98	10.10	579.63	15.26	574.48	12.37	577.36
SWB-5	10-20	589.97	15.17	574.80	15.13	574.84	15.00	574.97	10.37	579.61	15.57	574.40	12.65	577.32
SWB-6	48-53	589.28	--	--	39.50	--	30.70	--	48.76	--	38.95	550.33	--	--
SWB-7	12-22	589.14	8.40	580.74	9.11	580.03	9.79	579.35	8.34	580.81	9.25	579.89	8.20	580.94
SWB-8	9-19	588.95	--	--	--	--	--	--	--	--	11.54	577.41	9.73	579.22
Piezometer														
P-1	30-40	598.35	12.41	585.94	12.19	586.16	12.44	585.91	10.57	587.79	12.17	586.18	10.88	587.47
P-2	13-23	593.36	4.28	589.08	5.07	588.29	5.12	588.24	4.24	589.12	5.59	587.77	4.71	588.65
P-3	14-24	593.23	5.57	587.66	5.52	587.71	7.70	585.53	4.77	588.46	5.98	587.25	4.93	588.30
P-4	14-24	592.96	8.60	584.36	9.19	583.77	9.08	583.88	7.59	585.37	8.47	584.49	7.78	585.18
P-5	47-52	593.10	8.80	584.30	8.85	584.25	8.67	584.43	7.58	585.52	8.29	584.81	7.50	585.60
P-6	10-20	594.18	10.60	583.58	10.46	583.72	10.34	583.84	9.21	584.97	9.66	584.52	9.27	584.91
P-7	13-23	592.87	--	--	--	--	--	--	--	--	--	--	--	--
P-7A	12-22	592.68	7.11	585.57	5.92	586.76	8.01	584.67	7.26	585.42	7.91	584.77	6.12	586.56
P-8	15-25	592.68	9.30	583.38	9.71	582.97	9.89	582.79	9.40	583.29	9.74	582.94	9.02	583.66
P-9	11-21	589.95	9.80	580.15	10.20	579.75	11.81	578.14	8.36	581.59	12.29	577.66	--	--
P-10	14-24	588.98	7.07	581.91	7.15	581.83	9.07	579.91	7.60	581.38	9.54	579.44	8.69	580.29
P-11	15-25	592.72	11.64	581.08	12.43	580.29	12.31	580.41	11.35	581.37	12.28	580.44	11.65	581.07
P-12	20-30	591.01	20.90	570.11	20.78	570.23	20.84	570.17	20.12	570.89	20.84	570.17	20.05	570.96
P-13	45-50	590.82	26.35	564.47	26.50	564.32	26.88	563.94	22.91	567.91	26.74	564.08	26.00	564.82
Staff Gauge														
I&M Canal		586.12	1.70	577.82	2.20	578.32	--	--	3.35	579.47	1.80	577.92	--	--
NW SWB		576.25	8.30	574.55	8.50	574.75	--	--	13.40	579.65	8.00	574.25	--	--
TWB		587.98	9.80	583.78	10.80	584.78	--	--	10.00	583.98	10.00	583.98	10.40	584.38
GCSA		569.72	12.50	557.22	10.46	559.26	--	--	2.00	567.72	9.83	559.89	--	--

TABLE 3-3

SUMMARY OF WATER LEVEL ELEVATIONS (ft. MSL) IN THE VICINITY OF THE SWB

Monitoring Well	Screen Interval	TOR Elevation	04/23/93 Depth to Water	04/23/93 Water Level Elevation	05/24/93 Depth to Water	05/24/93 Water Level Elevation	06/28/93 Depth to Water	06/28/93 Water Level Elevation	07/23/93 Depth to Water	07/23/93 Water Level Elevation	08/24/93 Depth to Water	08/24/93 Water Level Elevation	09/22/93 Depth to Water	09/22/93 Water Level Elevation
SWB-1	16-26	592.43	19.05	573.38	19.57	572.86	19.08	573.35	20.9	571.53	19.75	572.68	19.62	572.81
SWB-2	17-27	588.90	19.45	569.45	20.23	568.67	19.36	569.54	20.05	568.85	20.1	568.80	16.69	572.21
SWB-3	10-20	588.53	11.81	576.72	13.42	575.11	12.1	576.43	13.38	575.15	14.27	574.26	11.71	576.82
SWB-4	46-51	589.73	12.77	576.96	14.52	575.21	13.51	576.22	14.46	575.27	15.2	574.53	12.71	577.02
SWB-5	10-20	589.97	13.10	576.87	14.77	575.20	13.59	576.38	14.75	575.22	15.55	574.42	13.05	576.92
SWB-6	48-53	589.28	39.11	550.17	31.41	557.87	25.05	564.23	45.84	543.44	36.85	552.43	--	--
SWB-7	12-22	589.14	7.38	581.76	9.75	579.39	7.99	581.15	9.66	579.48	8.95	580.19	7.33	581.81
SWB-8	9-19	588.95	9.24	579.71	11.01	577.94	9.85	579.10	10.44	578.51	10.26	578.69	10.10	578.85
Piezometer														
P-1	30-40	598.35	10.55	587.80	12.25	586.10	12.43	585.92	13.10	585.25	13	585.35	12.65	585.70
P-2	13-23	593.36	4.81	588.55	5.51	587.85	5.02	588.34	5.91	587.45	5.54	587.82	5.07	588.29
P-3	14-24	593.23	4.89	588.34	5.73	587.50	5.48	587.75	5.82	587.41	5.32	587.91	4.89	588.34
P-4	14-24	592.96	7.71	585.25	8.45	584.51	8.15	584.81	8.75	584.21	8.78	584.18	8.82	584.14
P-5	47-52	593.10	7.50	585.61	8.29	584.81	8.05	585.05	8.40	584.70	8.37	584.73	8.37	584.73
P-6	10-20	594.18	9.57	584.61	10.10	584.08	9.65	584.53	10.54	583.64	9.32	584.86	9.62	584.56
P-7	13-23	592.87	--	--	--	--	--	--	--	--	--	--	--	--
P-7A	12-22	592.68	6.28	586.40	6.61	586.07	7.66	585.02	7.48	585.20	7.495	585.19	7.72	584.96
P-8	15-25	592.68	9.18	583.50	9.47	583.21	9.69	582.99	9.47	583.21	9.35	583.33	9.80	582.88
P-9	11-21	589.95	8.89	581.06	12.96	576.99	10.55	579.40	13.10	576.85	11.95	578.00	8.76	581.19
P-10	14-24	588.98	6.47	582.51	10.25	578.73	7.64	581.34	10.77	578.21	10.26	578.72	5.86	583.12
P-11	15-25	592.72	10.61	582.11	11.80	580.92	11.76	580.96	11.87	580.85	11.90	580.82	11.32	581.40
P-12	20-30	591.01	20.29	570.72	20.83	570.18	20.53	570.48	20.84	570.17	23.27	567.74	26.78	564.23
P-13	45-50	590.82	25.97	564.85	26.82	564.00	25.22	565.60	26.52	564.30	26.36	564.46	26.10	564.72
Staff Gauge														
I&M Canal		586.12	2.58	578.70	1.80	577.92	2.10	578.22	1.70	577.82	1.80	577.92	2.00	578.12
NW SWB		576.25	10.50	576.75	8.80	575.05	10.20	576.45	9.80	576.05	--	--	10.50	576.75
TWB		587.98	9.40	583.38	9.90	583.88	9.20	583.18	10.80	584.78	9.80	583.78	8.40	582.38
GCSA		569.72	12.25	557.47	12.60	557.12	4.10	565.62	9.30	560.42	8.10	561.62	8.90	560.82

TABLE 3-3

Monitoring Well	Screen Interval	TOR Elevation	10/27/93 Depth to Water	Water Level Elevation
SWB-1	16-26	592.43	20.02	572.41
SWB-2	17-27	588.90	20.16	568.74
SWB-3	10-20	588.53	14.46	574.07
SWB-4	46-51	589.73	15.43	574.30
SWB-5	10-20	589.97	15.78	574.19
SWB-6	48-53	589.28	41.1	548.18
SWB-7	12-22	589.14	9.82	579.32
SWB-8	9-19	588.95	12.28	576.67
Piezometer				
P-1	30-40	598.35	12.63	585.72
P-2	13-23	593.36	5.56	587.80
P-3	14-24	593.23	5.97	587.26
P-4	14-24	592.96	9.23	583.73
P-5	47-52	593.10	8.78	584.32
P-6	10-20	594.18	8.09	586.09
P-7	13-23	592.87	--	--
P-7A	12-22	592.68	5.49	587.19
P-8	15-25	592.68	8.71	583.97
P-9	11-21	589.95	12.62	577.33
P-10	14-24	588.98	9.30	579.68
P-11	15-25	592.72	11.68	581.04
P-12	20-30	591.01	20.77	570.24
P-13	45-50	590.82	24.60	566.22
Staff Gauge				
I&M Canal		586.12	2.10	578.22
NW SWB		576.25	8.50	574.75
TWB		587.98	--	--
GCSA		569.72	5.70	564.02

TABLE 3-4

Summary of Volatile Organic Compounds in Stormwater Basin Monitoring Wells January through September 1993

Compound (µg/l)	Date	Monitoring Well SWB-1	SWB-2	SWB-3	SWB-4	SWB-5	SWB-6	SWB-7	SWB-8
Benzene	1/6/93	30	52	<5	<5	<5	6	620	6,000[1]
	6/29/93	76	35	<5	<5	<5	<5	730	4,300
	9/24/93	41	55	<250	<5	<5	<5	630	3,200
Toluene	1/6/93	<5	<5	<5	<5	<5	<5	530	2,900[1]
	6/29/93	<5	<5	<5	<5	<5	<5	680	2,800
	9/24/93	<5	<12	<250	<5	<5	<5	560	2,600
Ethylbenzene	1/6/93	<5	62	<5	<5	<5	<5	140	560[1]
	6/29/93	<5	70	<5	<5	<5	<5	130	470
	9/24/93	<5	47	<250	<5	<5	<5	140	470
Xylene	1/6/93	6	91	<5	<5	<5	<5	540	2,600[1]
	6/29/93	14	97	<5	<5	<5	8	590	3,500
	9/24/93	<5	85	<250	<5	<5	<5	540	3,000

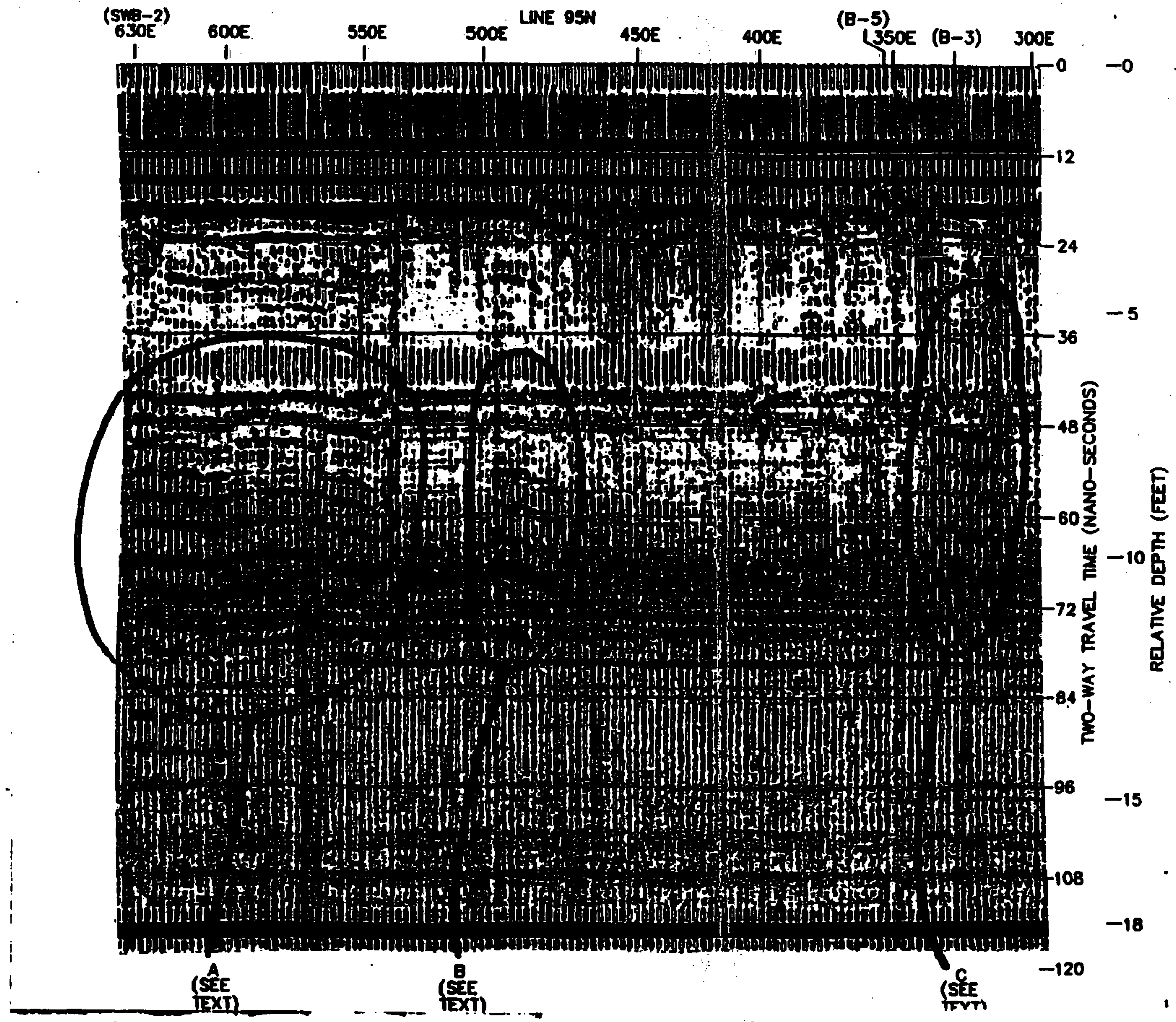
[1]Samples were collected on February 24, 1993.
< = Less than the detection limit.

TABLE 3-5

Summary of Semivolatile Organic Compounds in Stormwater Basin Monitoring Wells January through September 1993

		Monitoring Well							
Compound (μg/l)	Date	SWB-1	SWB-2	SWB-3	SWB-4	SWB-5	SWB-6	SWB-7	SWB-8
Phenol	1/6/93	<10	<11	<10	<10	<10	55	4,600	<21[1]
	6/29/93	<10	<10	<10	<10	<10	<10	<40	<42
	9/24/93	<10	<10	<250	<10	<10	<10	5,200	200
Naphthalene	1/6/93	<10	<11	<10	<10	<10	<10	<400	150[1]
	6/29/93	<10	<10	<10	<10	<10	<10	65	200
	9/24/93	<10	<10	<250	<10	<10	<10	<200	340
2-Methylnapthalene	1/6/93	<10	<4	<10	<10	<10	<10	<400	67[1]
	6/29/93	<10	24	<10	<10	<10	<10	53	120
	9/24/93	<10	26	<350	<10	<10	<10	<200	210
4-Methylphenol	1/6/93	<10	<11	<10	<10	<10	<10	<400	<21
	6/29/93	<10	<10	<10	<10	<10	<10	<40	71
	9/24/93	<10	<10	<250	<10	<10	<10	<200	<100
2,4-Dimethylphenol	1/6/93	<10	<11	<10	<10	<10	<10	<400	<21
	6/29/93	<10	<10	<10	<10	<10	16	<40	<42
	9/24/93	<10	<10	<250	<10	<10	<10	<200	<100
2,4-Dichlorophenol	1/6/93	<10	<11	<10	<10	<10	<10	<400	<21
	6/29/93	<10	<10	<10	<10	<10	86	<40	<42
	9/24/93	<10	<10	<250	<10	<10	<10	<200	<100
2,4,5-Trichlorophenol	1/6/93	<20	<22	<20	<20	<20	<20	<800	<42
	6/29/93	<20	<20	<20	<21	<27	340	<80	<84
	9/24/93	<50	<50	<1,200	<50	<50	<50	<1,000	<500
2,4,6-Trichlorophenol	1/6/93	<10	<11	<10	<10	<10	<10	<400	<21
	6/29/93	<10	<10	<10	<10	<10	<10	<170	<42
	9/24/93	<10	<10	<250	<10	<10	64	<200	<100
2-Methylphenol	1/6/93	<10	<11	<10	<10	<10	<10	<400	<21
	6/29/93	<10	<10	<10	<10	<10	<10	<40	<42
	9/24/93	<10	<10	<250	<10	<10	<10	280	150
3+4-Methylphenol	1/6/93	<10	<11	<10	<10	<10	<10	<400	<21
	6/29/93	<10	<10	<10	<10	<10	<10	<40	<42
	9/24/93	<10	<10	<250	<10	<10	<10	1,500	360
Di-n-butylphthalate	1/6/93	<10	<11	<10	<10	<10	<10	<400	<21
	6/29/93	<10	<10	<10	<10	<10	<10	<10	<40
	9/24/93	<10	<10	<250	26	29	13	<200	<100

[1]Samples were collected on February 24, 1993.
< = Less than the detection limit.



ENSR™
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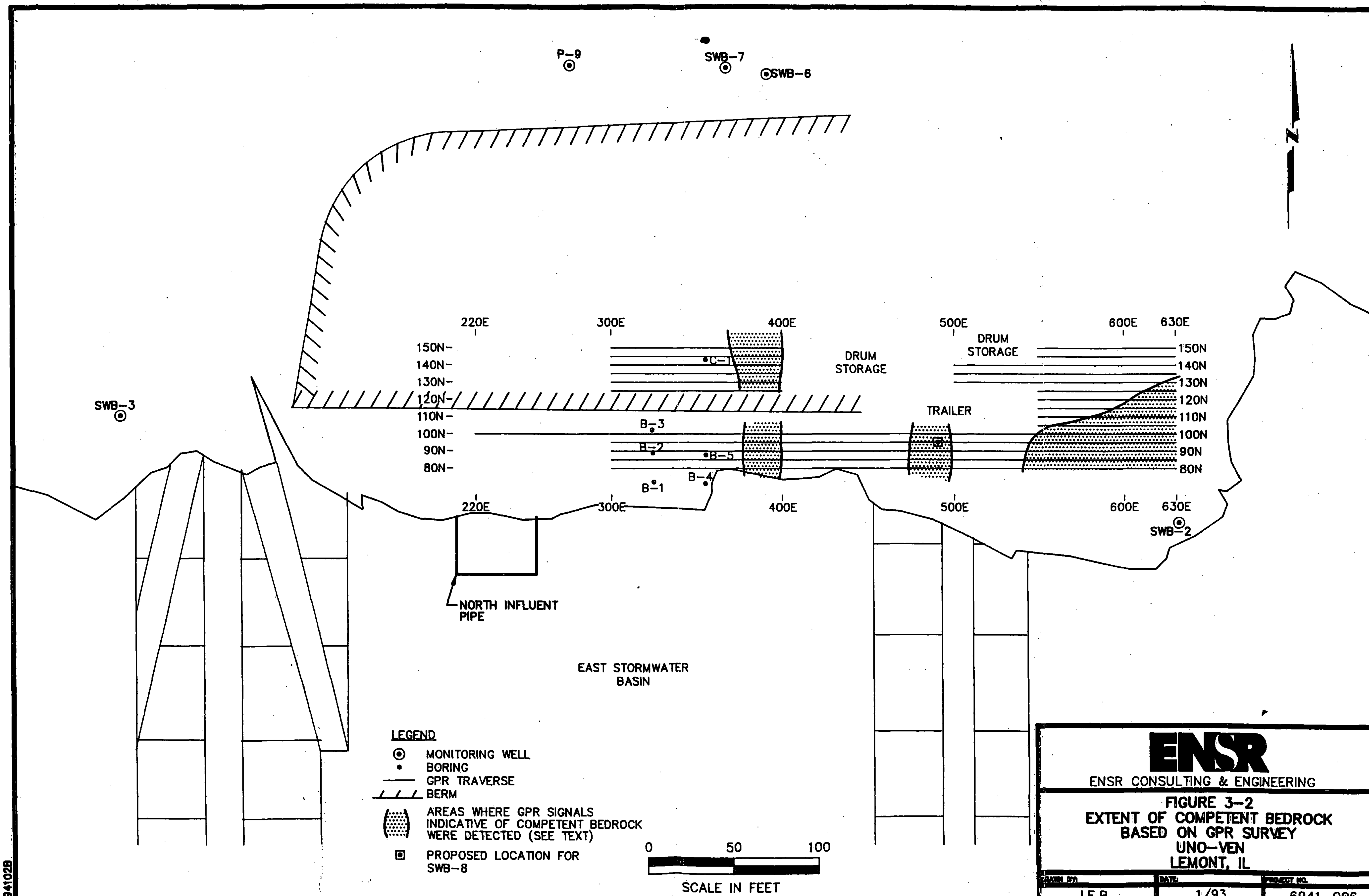
FIGURE 3-1
TYPICAL GPR RECORD
UNO-VEN
LEMONT, ILLINOIS

DRAWN: EDH	DATE: 11/18/93	PROJECT NUMBER: 6941-006	REV. 0
APPV'D: JS	REVISED: X		



ENSR

ENSR CONSULTING & ENGINEERING

FIGURE 3-2
EXTENT OF COMPETENT BEDROCK BASED ON GPR SURVEY
UNO-VEN
LEMONT, IL

DRAWN BY	DATE	PROJECT NO.
J.E.B.	1/93	6941-006

6941028

MONITORING WELL SWB-4

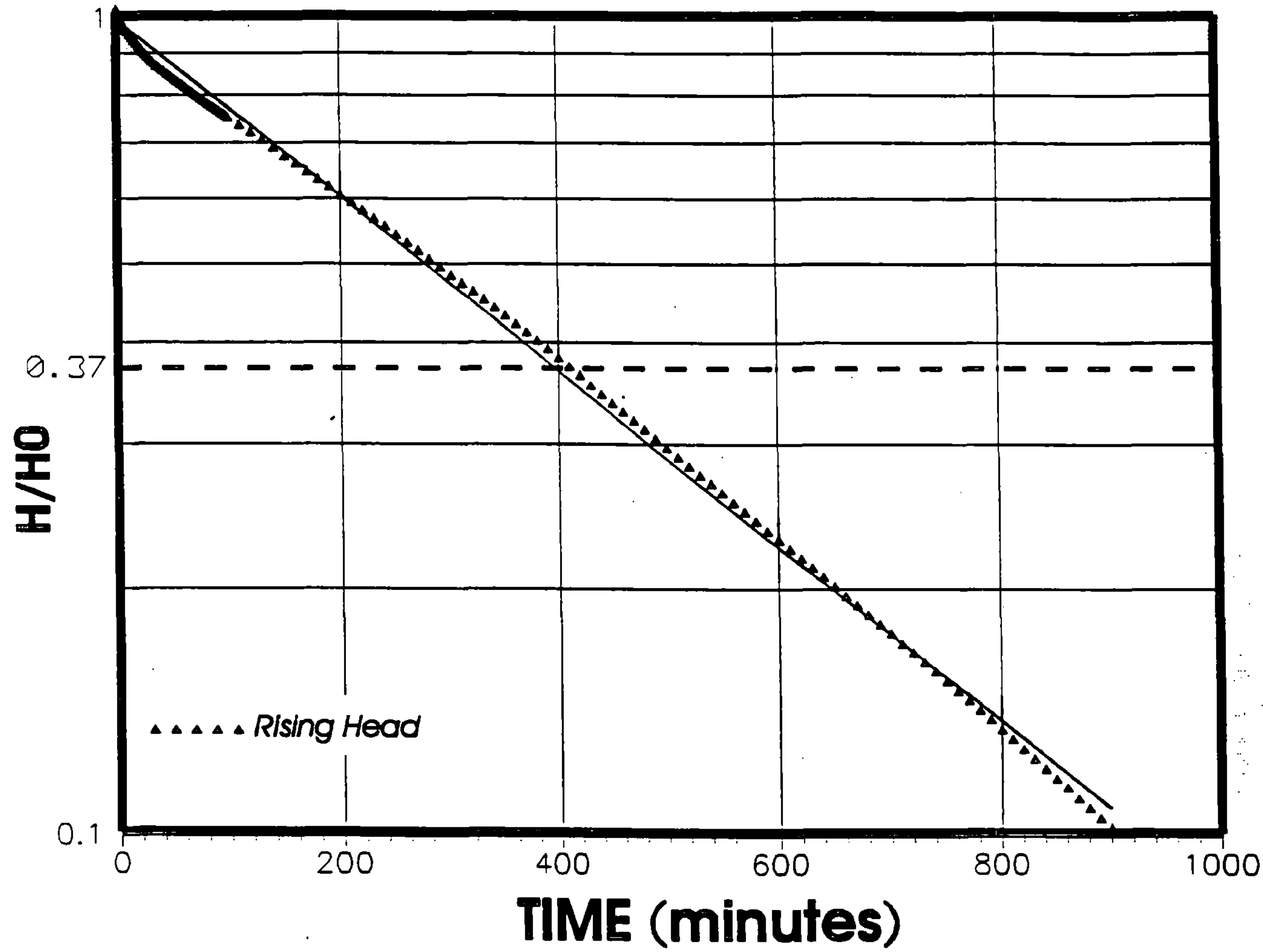


FIGURE 3-3

ENSR
Consulting and Engineering

HYDRAULIC CONDUCTIVITY TEST DATA PLOT FOR MONITORING WELL SWB-4

Drawn by: JDG	Date: 10/26/93	Project Number	Rev.
Appd. by: DM	Revised: x	6941-006	0

6941\SWB-4

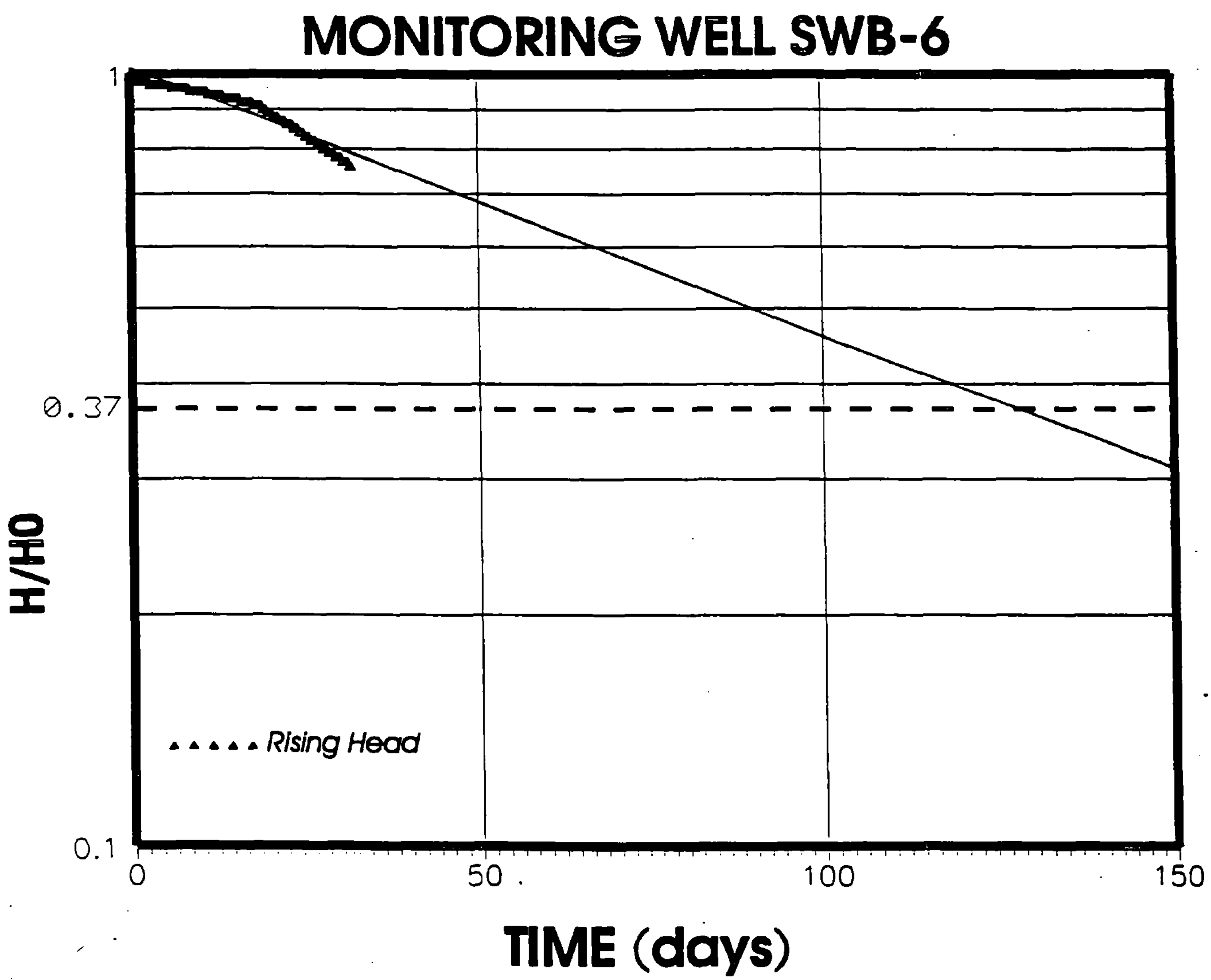


FIGURE 3-4

ENSR
Consulting and Engineering

HYDRAULIC CONDUCTIVITY TEST DATA PLOT FOR MONITORING WELL SWB-6

Drawn by: JDG	Date: 10/26/93	Project Number	Rev.
Appd. by: DM	Revised: x	6941-006	0

6941\SWB-6

MONITORING WELL SWB-7

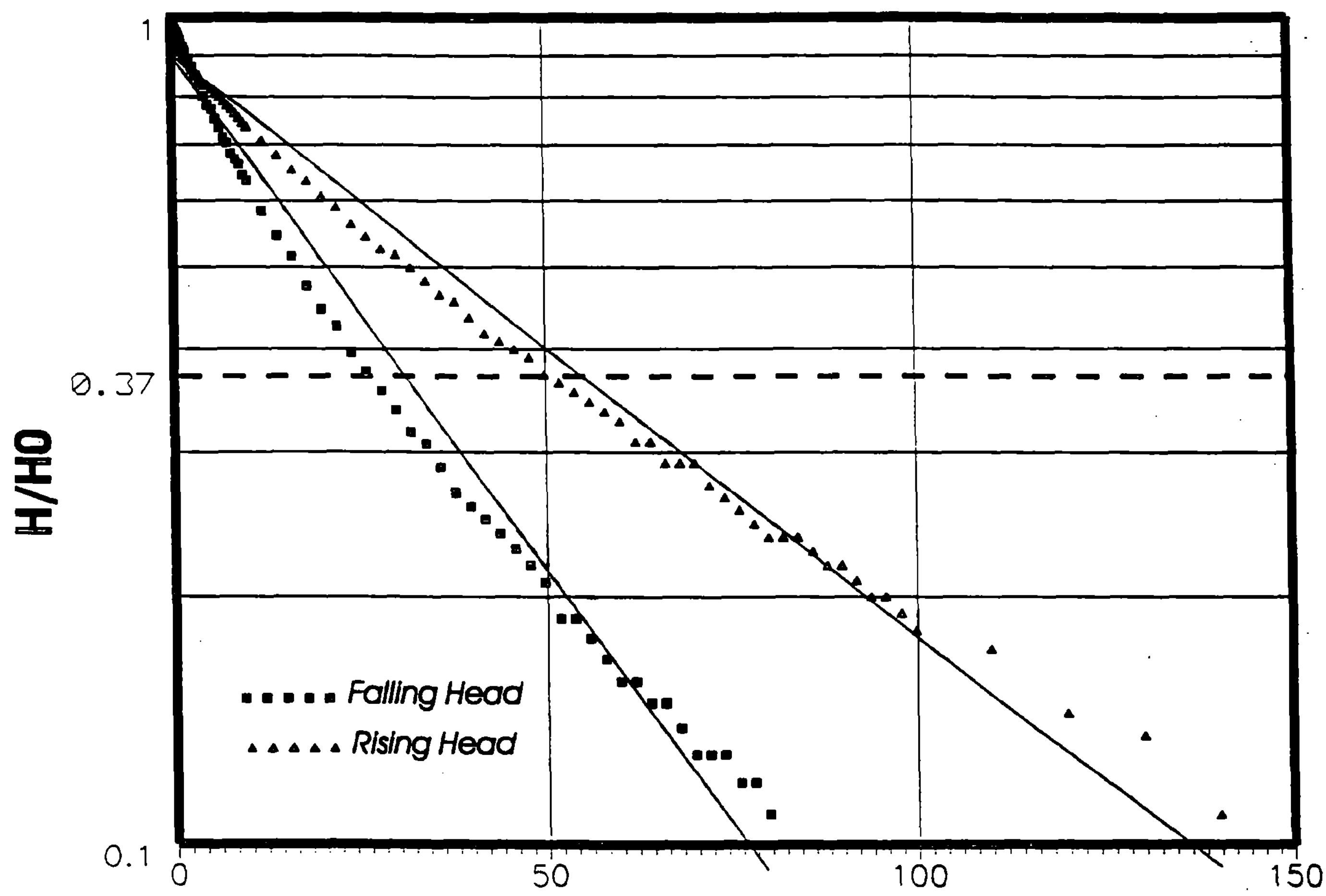


FIGURE 3-5

ENSR
Consulting and Engineering

HYDRAULIC CONDUCTIVITY TEST DATA PLOT FOR MONITORING WELL SWB-7

Drawn by: JDG	Date: 10/26/93	Project Number 6941-006	Rev. 0
Appd. by: DM	Revised: x		

6941\SWB-7

MONITORING WELL SWB-8

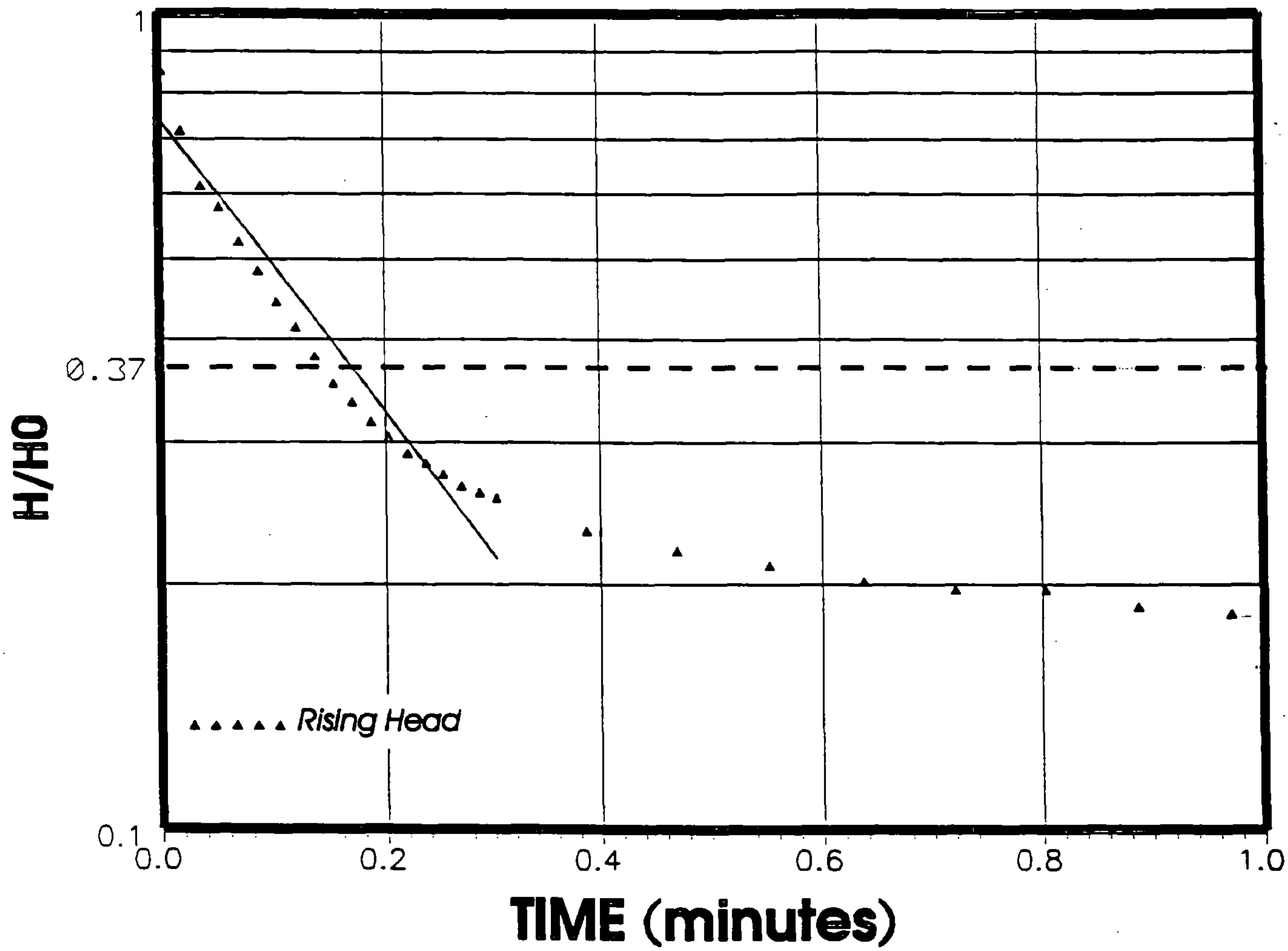


FIGURE 3-6

ENSR
Consulting and Engineering

HYDRAULIC CONDUCTIVITY TEST DATA PLOT FOR MONITORING WELL SWB-8

Drawn by: JDG	Date: 10/26/93	Project Number	Rev.
Appd. by: DM	Revised: x	6941-006	0

6941\SWB-8

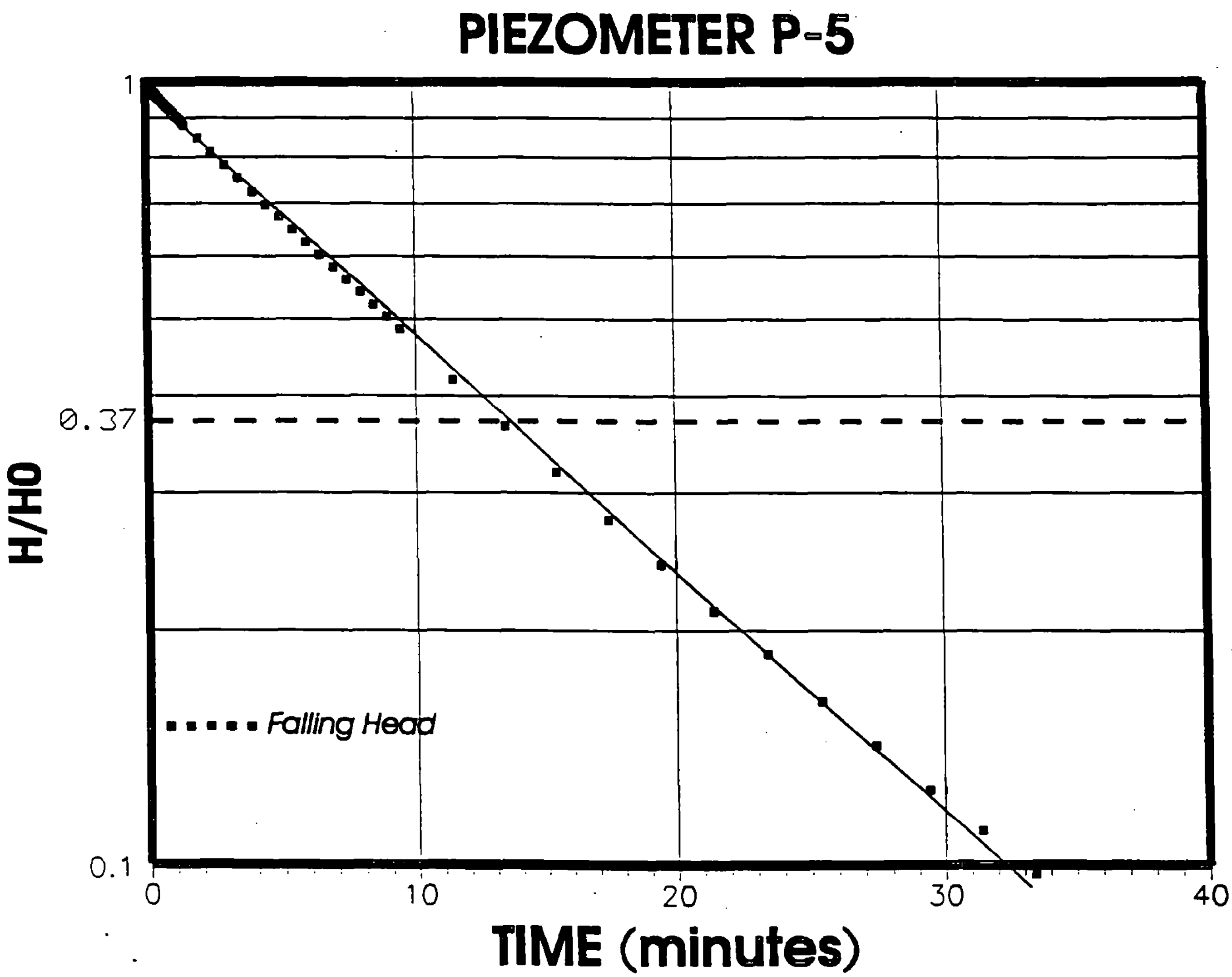


FIGURE 3-7

ENSR
Consulting and Engineering

HYDRAULIC CONDUCTIVITY TEST DATA PLOT FOR MONITORING WELL P-5

Drawn by: JDG	Date: 10/26/93	Project Number	Rev.
Appd. by: DM	Revised: x	6941-006	0

6941\P-5

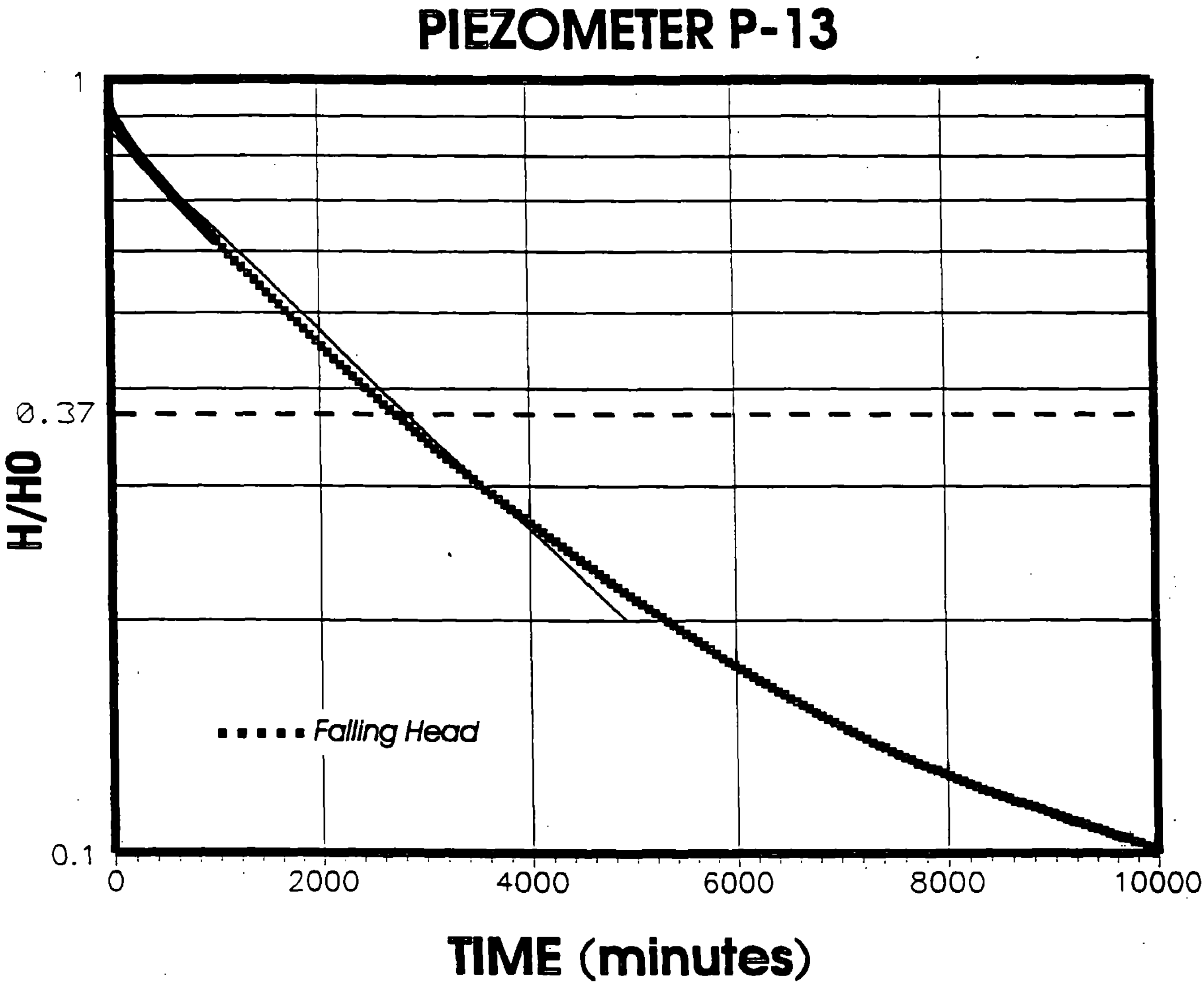


FIGURE 3-8

ENSR
Consulting and Engineering

HYDRAULIC CONDUCTIVITY TEST DATA PLOT FOR MONITORING WELL P-13

Drawn by: JDG	Date: 10/26/93	Project Number 6941-006	Rev. 0
Appd. by: DM	Revised: x		

6941\P-13

FIGURE 3-9

Summary of Water Level Elevations of the SWB

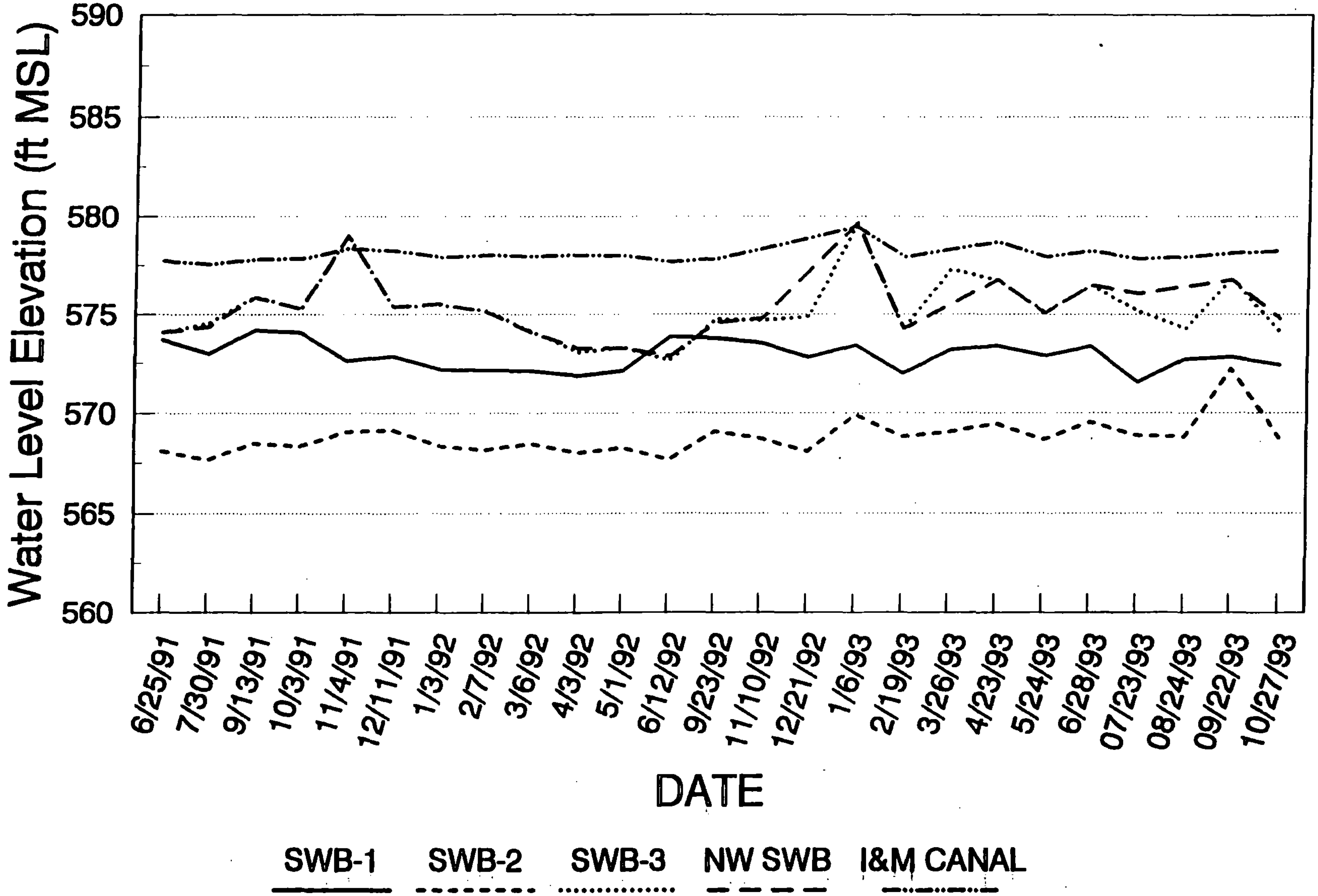


FIGURE 3-10

Summary of Water Level Elevations of the SWB

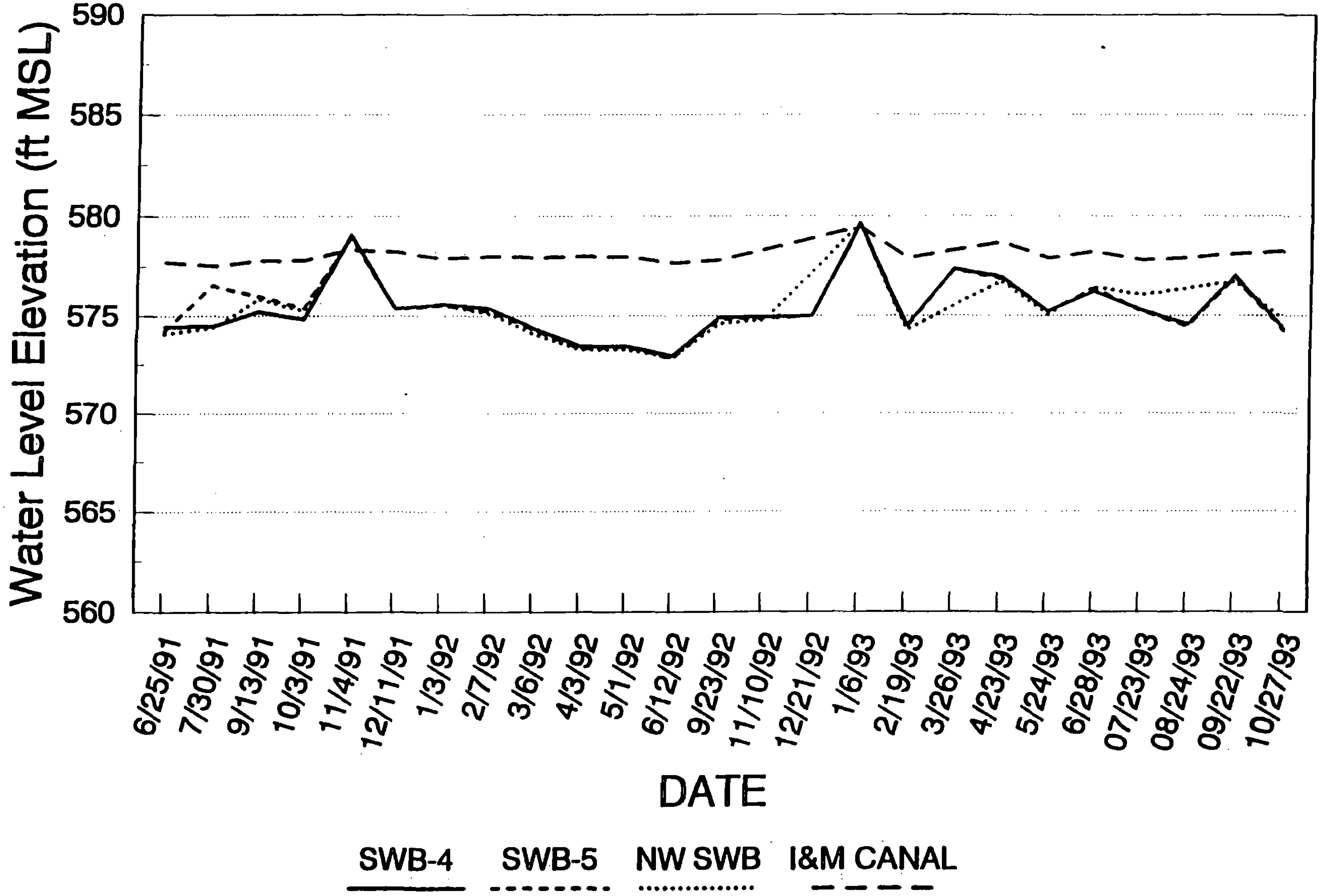


FIGURE 3-11

Summary of Water Level Elevations of the SWB

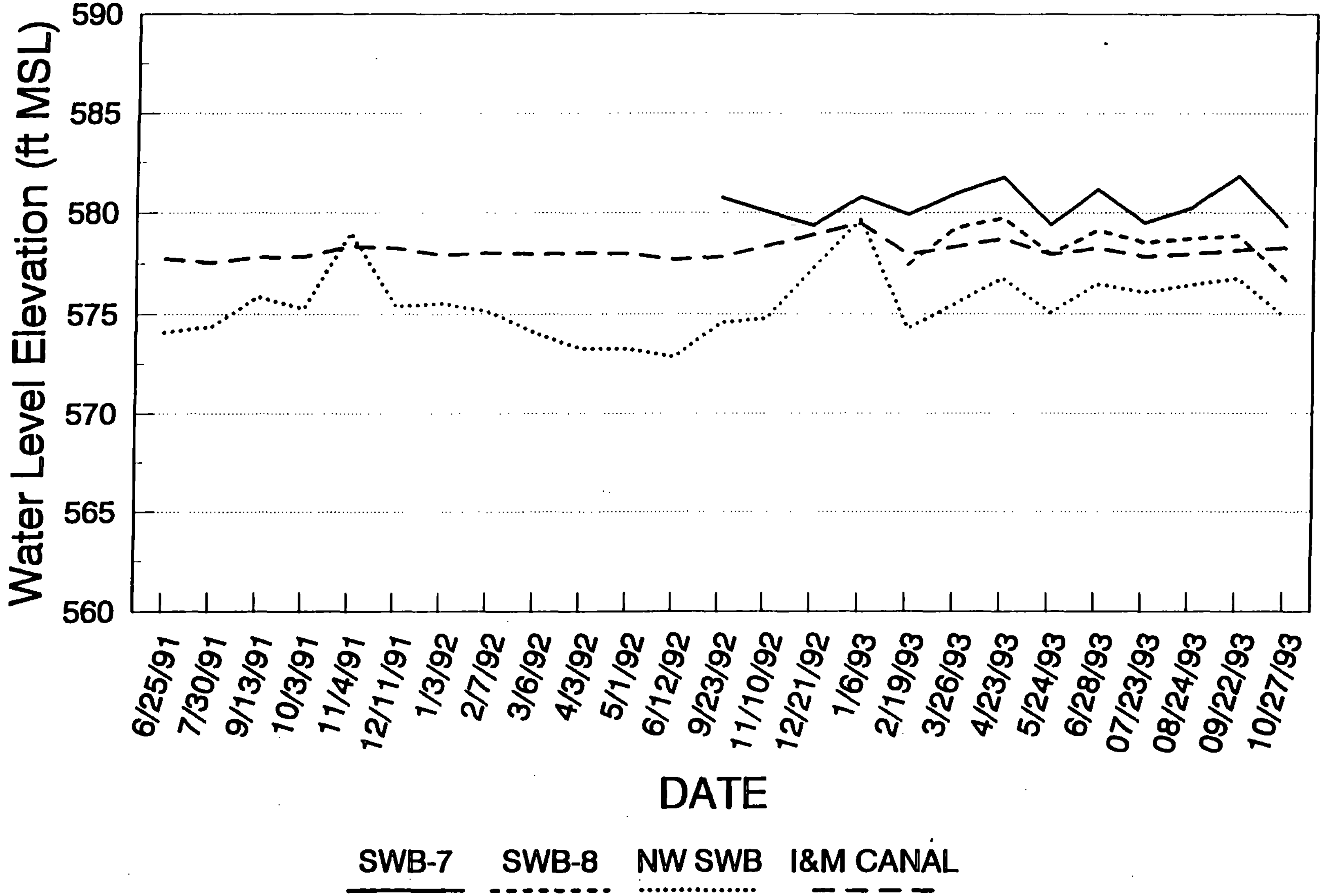


FIGURE 3-12

Summary of Water Level Elevations of the SWB

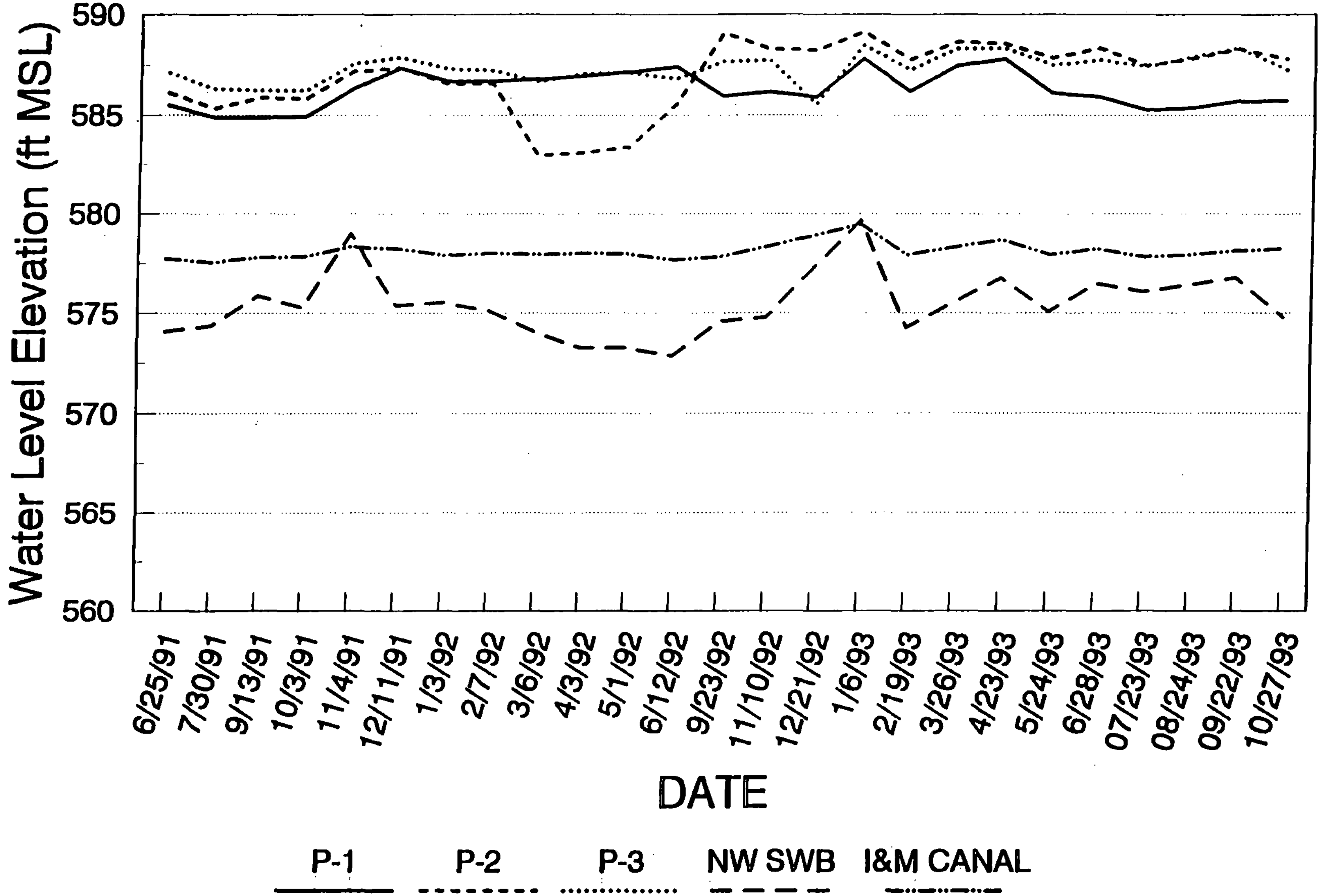
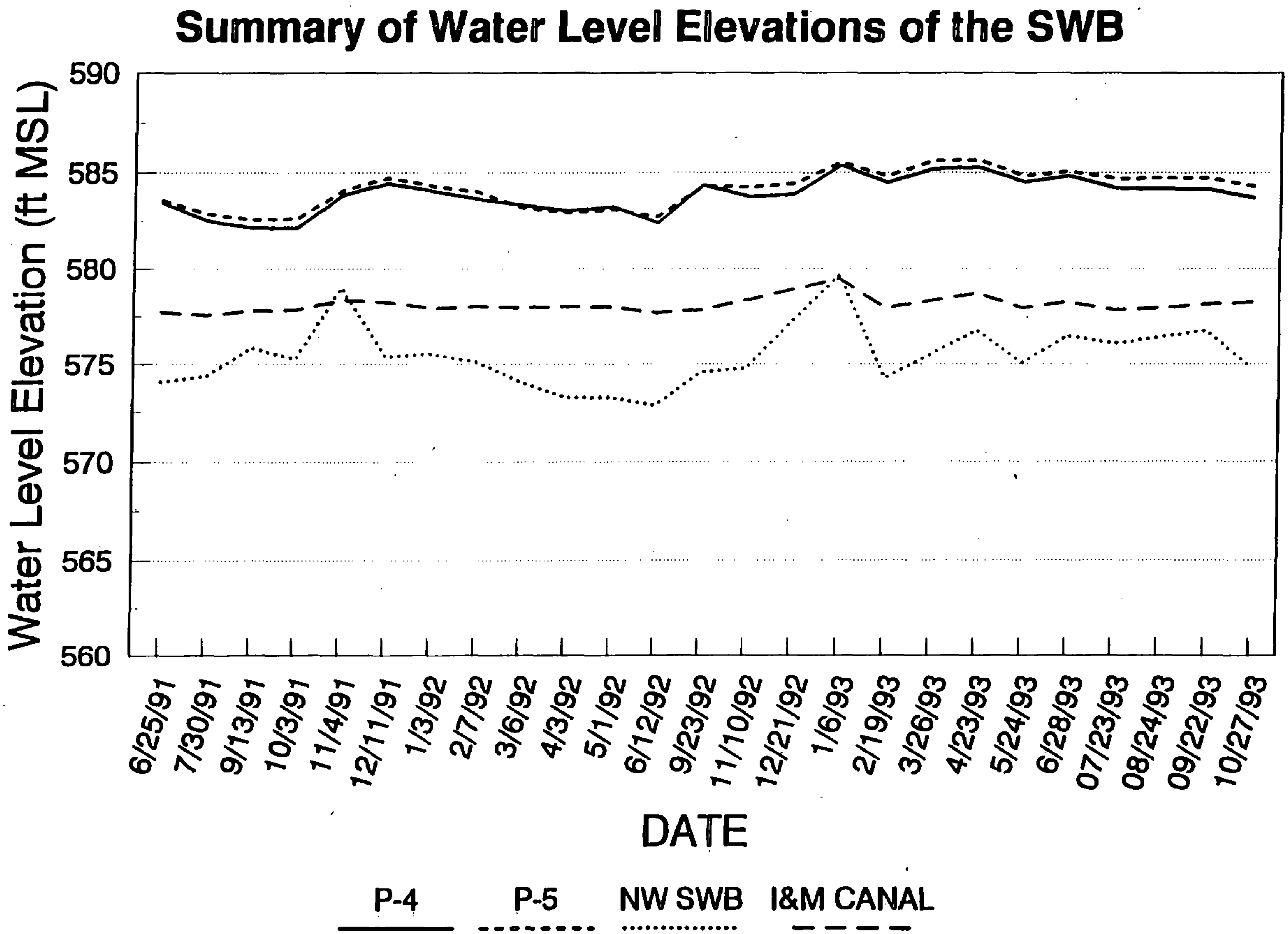


FIGURE 3-13



Summary of Water Level Elevations of the SWB
Water Level Elevation (ft MSL)
590
585
580
575
570
565
560
6/25/91
7/30/91
9/13/91
10/3/91
11/4/91
12/11/91
1/3/92
2/7/92
3/6/92
4/3/92
5/1/92
6/12/92
9/23/92
11/10/92
12/21/92
1/6/93
2/19/93
3/26/93
4/23/93
5/24/93
6/28/93
07/23/93
08/24/93
09/22/93
10/27/93
DATE
P-4
P-5
NW SWB
I&M CANAL

FIGURE 3-14

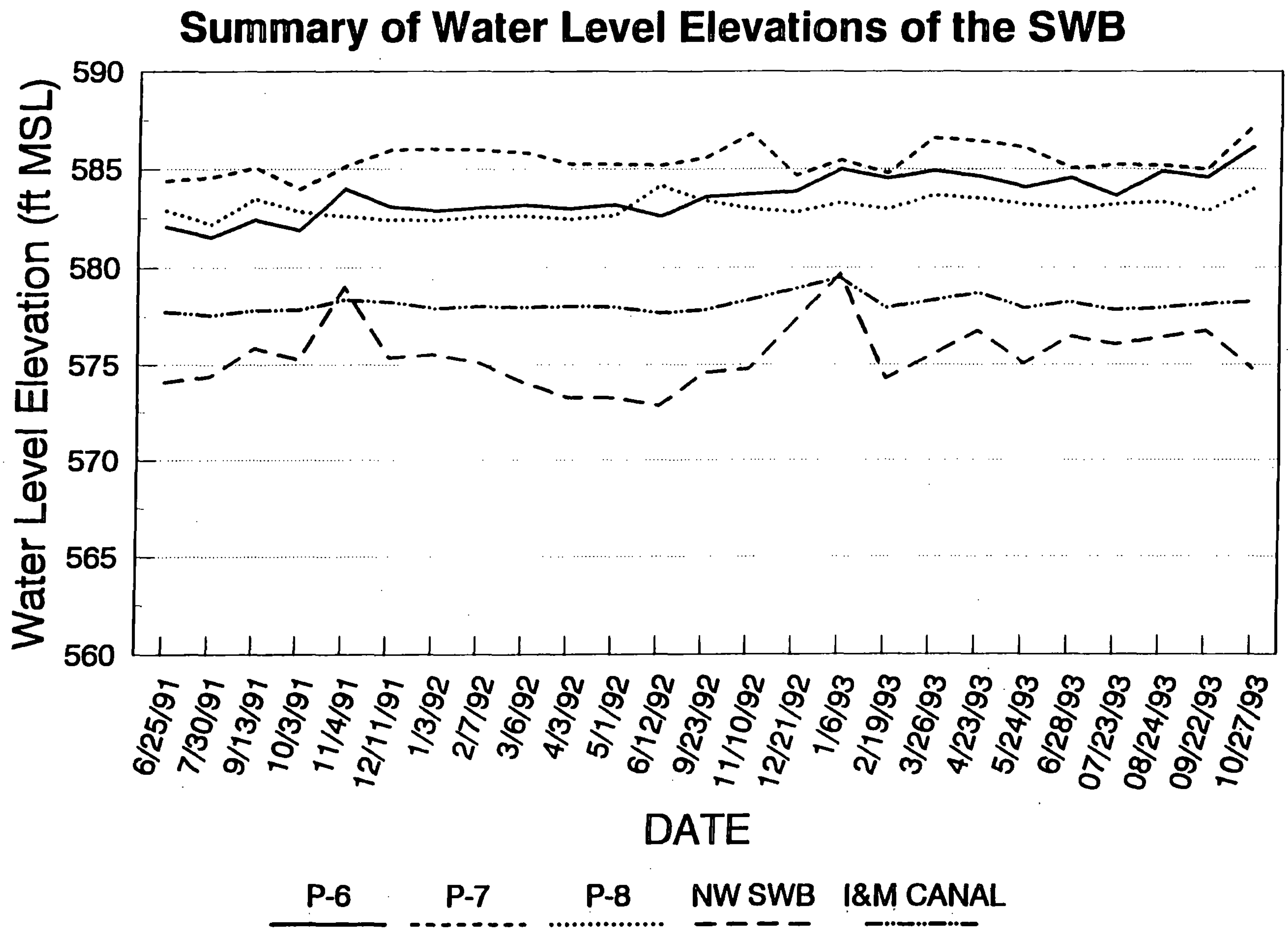

Summary of Water Level Elevations of the SWB
590
585
580
575
570
565
560
Water Level Elevation (ft MSL)
6/25/91
7/30/91
9/13/91
10/3/91
11/4/91
12/11/91
1/3/92
2/7/92
3/6/92
4/3/92
5/1/92
6/12/92
9/23/92
11/10/92
12/21/92
1/6/93
2/19/93
3/26/93
4/23/93
5/24/93
6/28/93
07/23/93
08/24/93
09/22/93
10/27/93
DATE
P-6
P-7
P-8
NW SWB
I&M CANAL

FIGURE 3-15

Summary of Water Level Elevations of the SWB

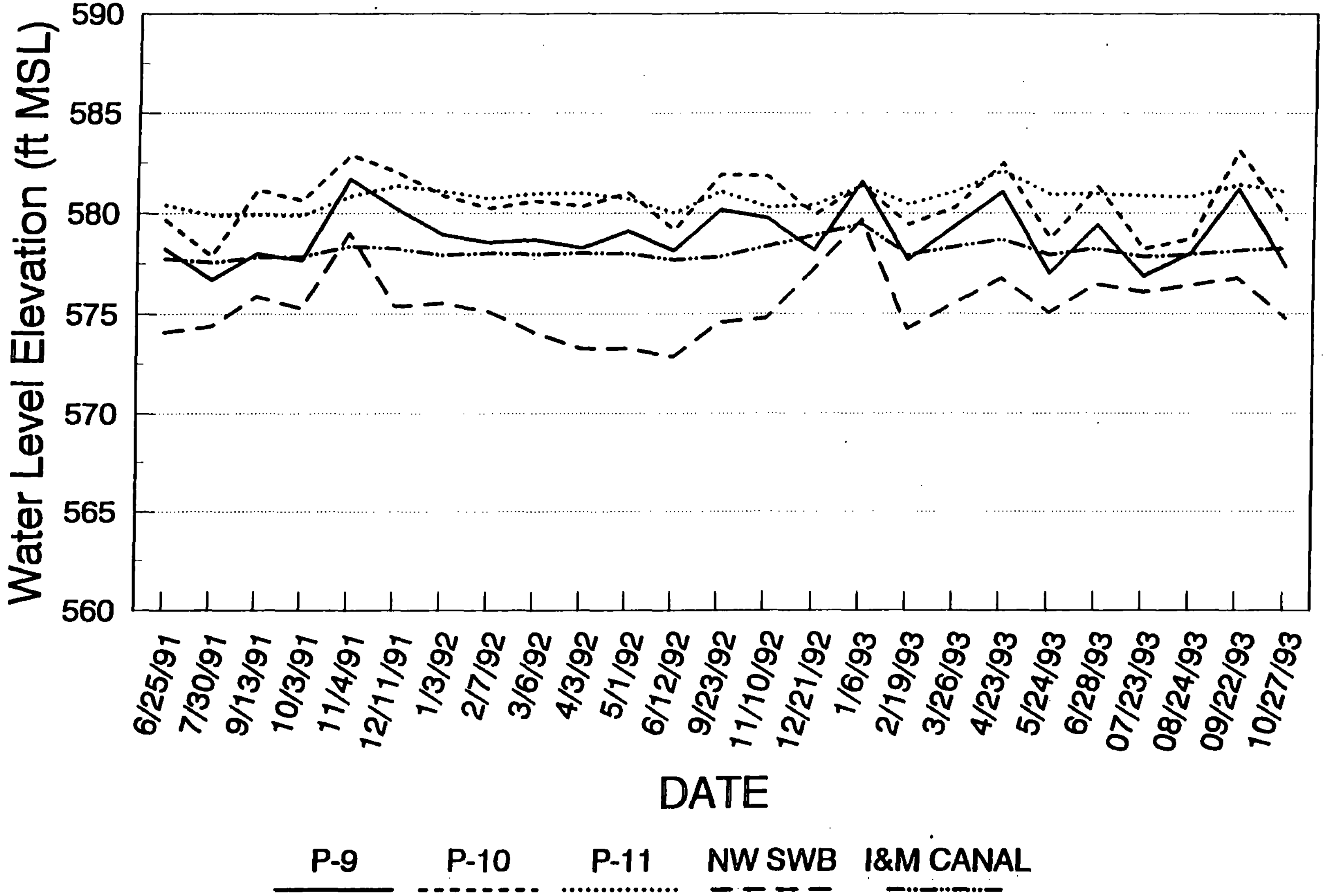
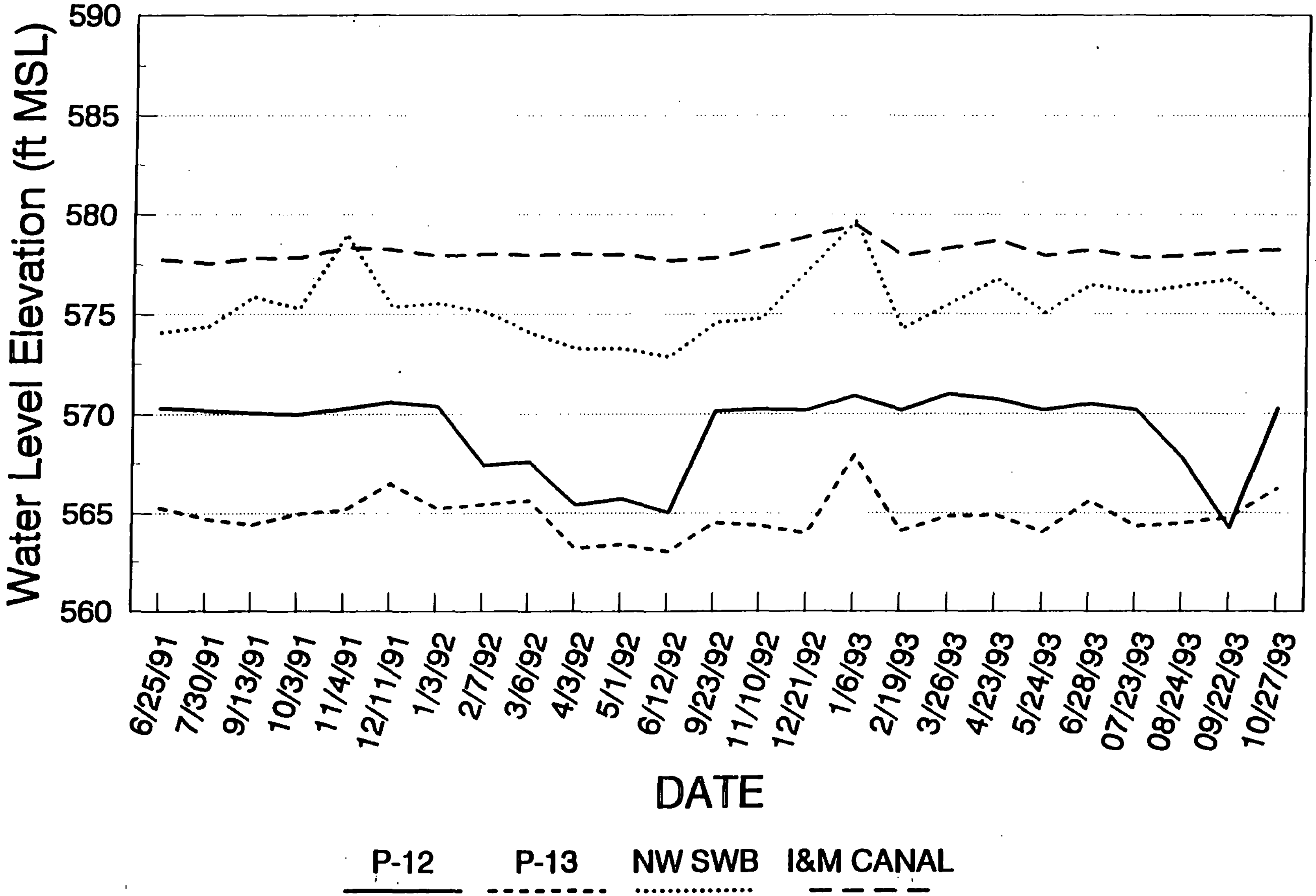


FIGURE 3-16

Summary of Water Level Elevations of the SWB



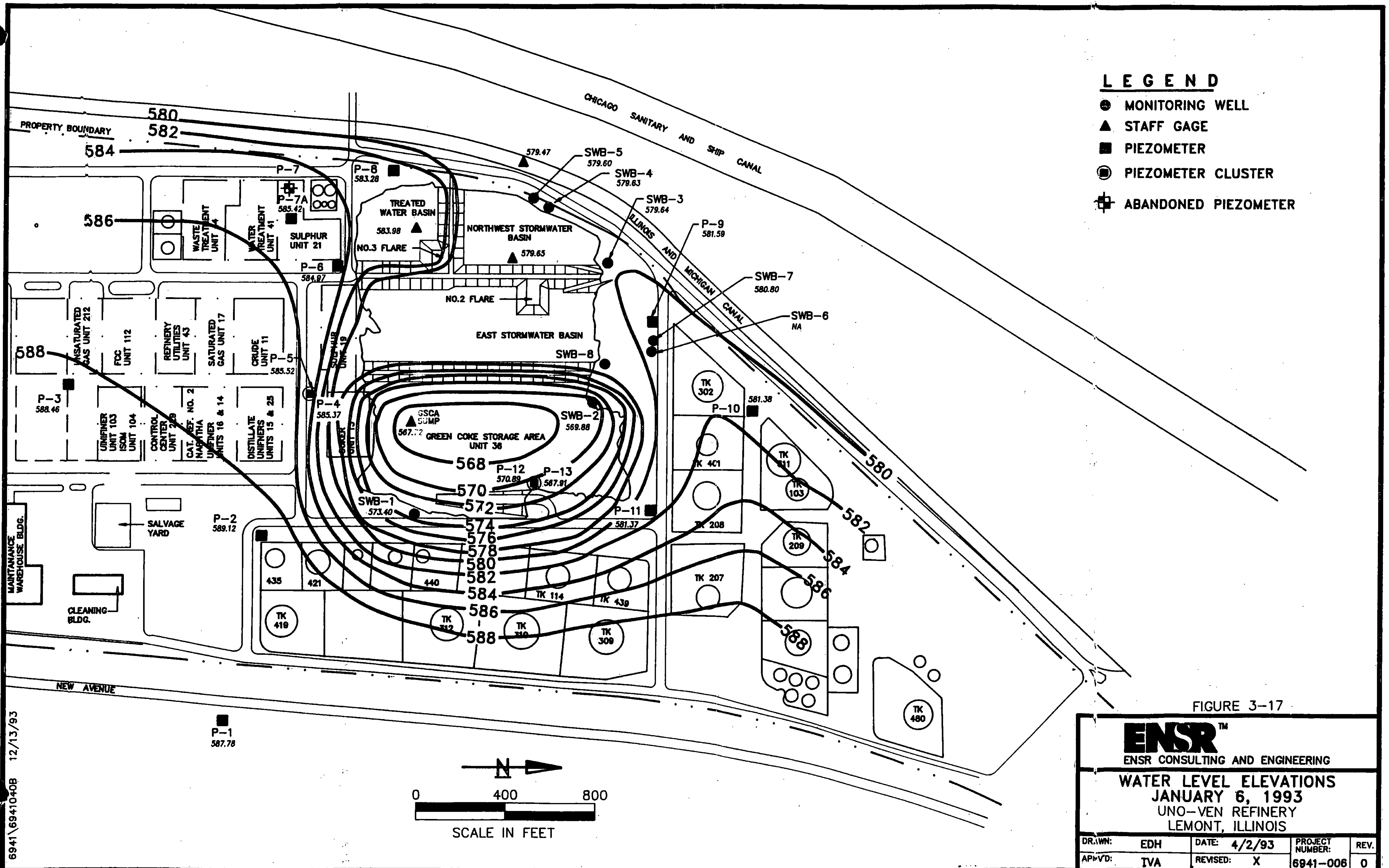


FIGURE 3-17

ENSR™
ENSR CONSULTING AND ENGINEERING

WATER LEVEL ELEVATIONS
JANUARY 6, 1993
UNO-VEN REFINERY
LEMONT, ILLINOIS

DRAWN:	EDH	DATE:	4/2/93	PROJECT NUMBER:	REV.
APP'VD:	TVA	REVISED:	X	6941-006	0

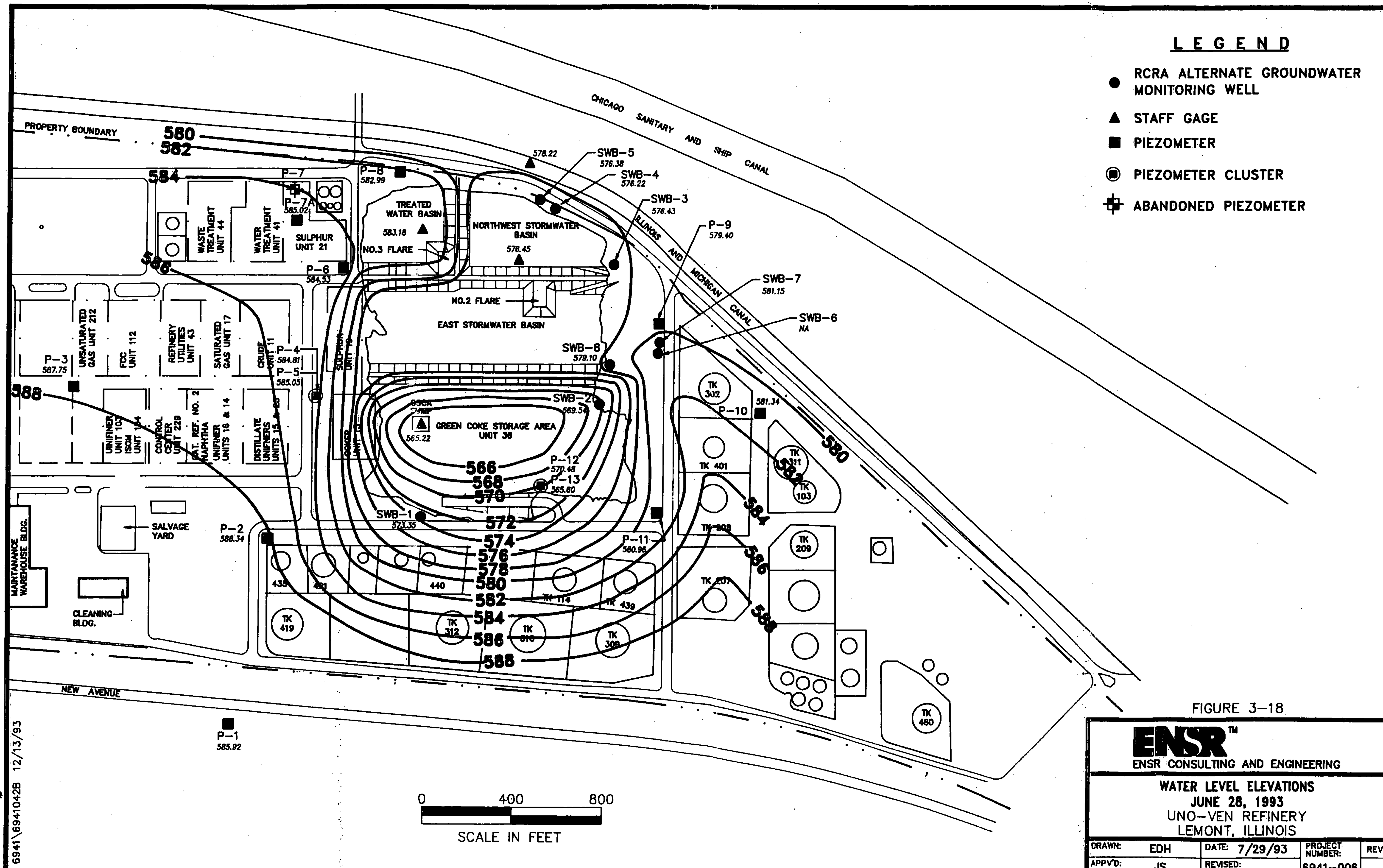


FIGURE 3-18

ENSR™
ENSR CONSULTING AND ENGINEERING

WATER LEVEL ELEVATIONS
JUNE 28, 1993
UNO-VEN REFINERY
LEMONT, ILLINOIS

DRAWN: EDH	DATE: 7/29/93	PROJECT NUMBER: 6941-006	REV.
APPV'D: JS	REVISED:		

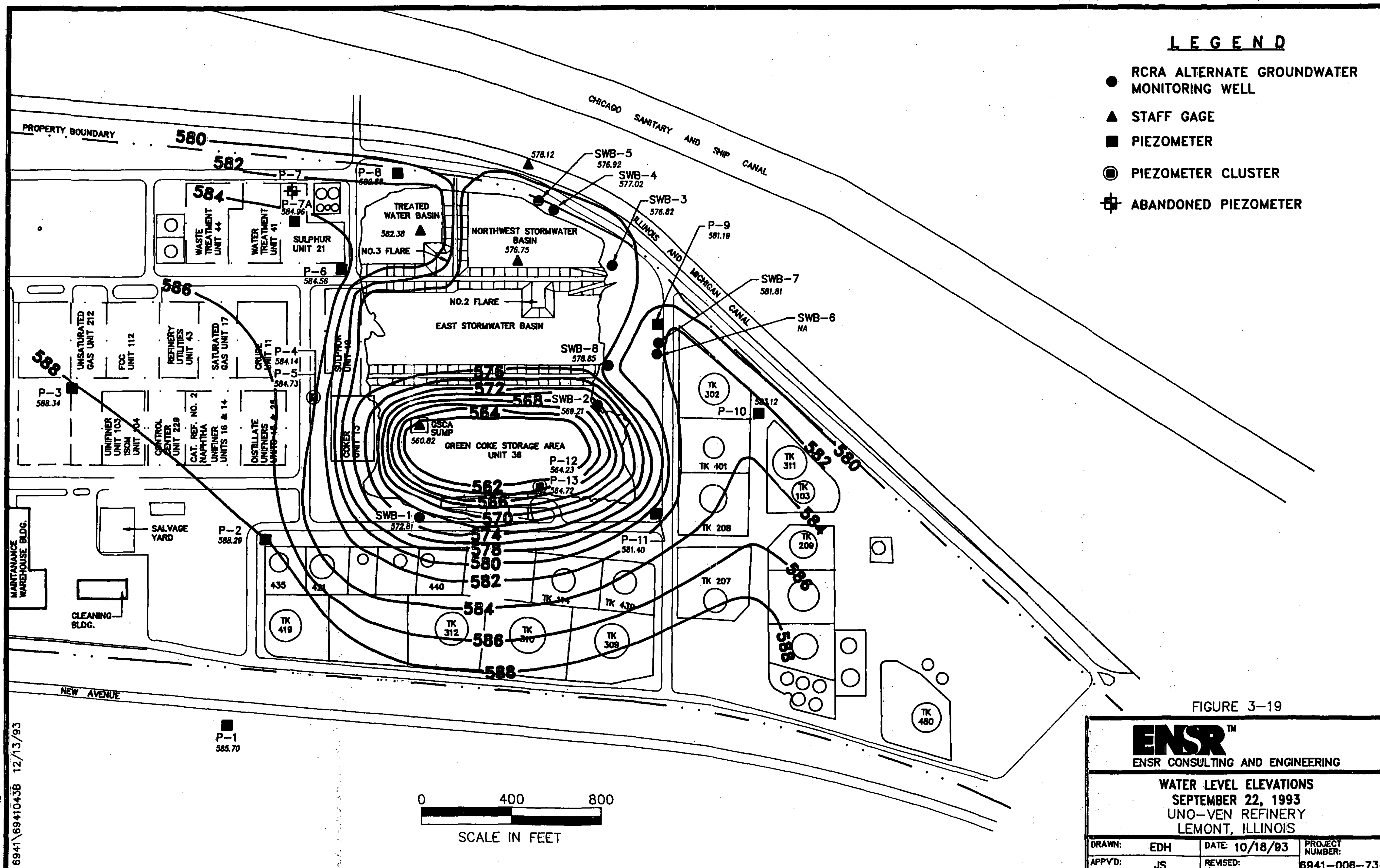


FIGURE 3-19

ENSR CONSULTING AND ENGINEERING

WATER LEVEL ELEVATIONS
SEPTEMBER 22, 1993
UNO-VEN REFINERY
LEMONT, ILLINOIS

DRAWN: EDH	DATE: 10/18/93	PROJECT NUMBER:	
APPV'D: JS	REVISED:	6941-006-734	

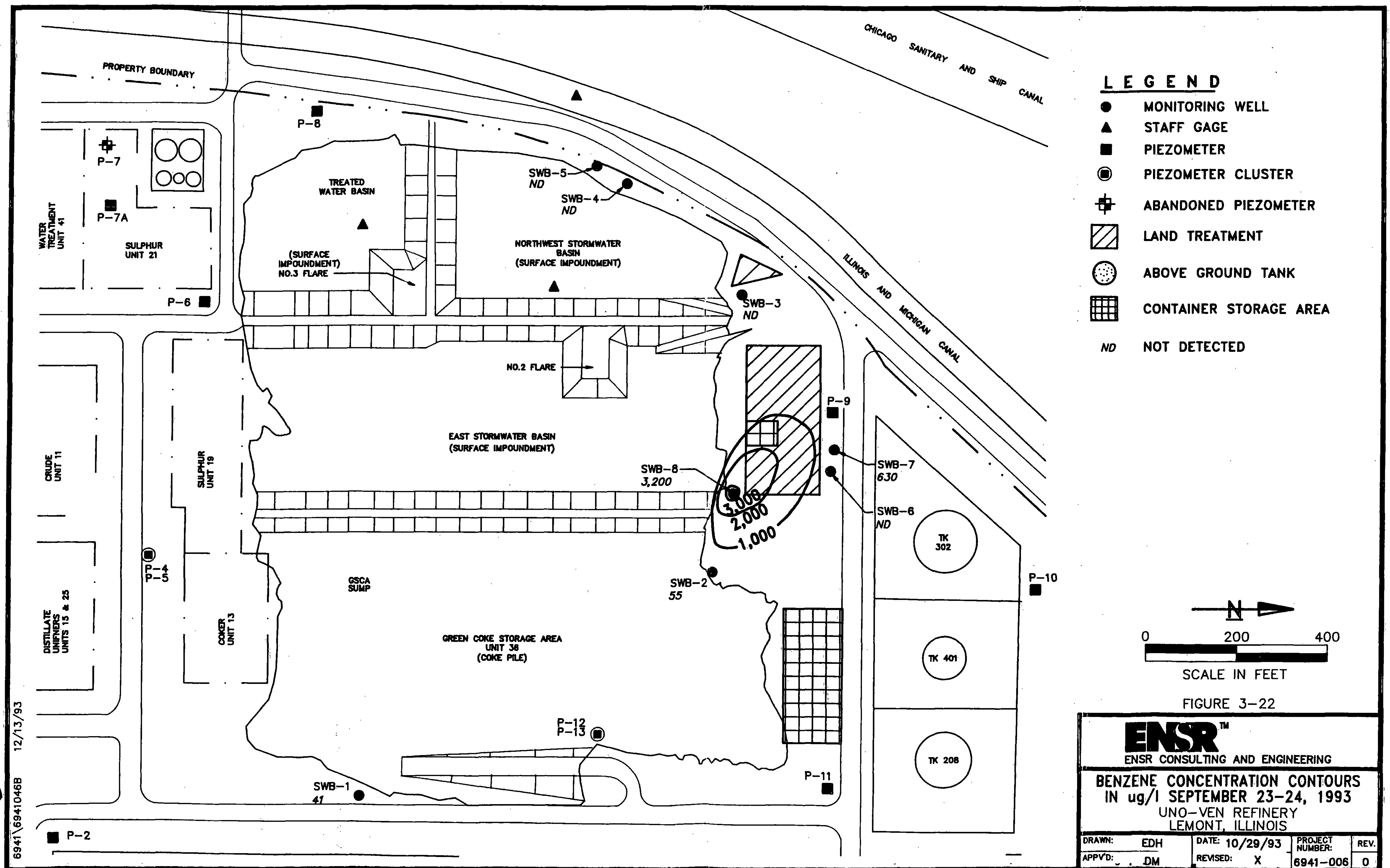


FIGURE 3-22

BENZENE CONCENTRATION CONTOURS IN ug/l SEPTEMBER 23-24, 1993
UNO-VEN REFINERY
LEMONT, ILLINOIS

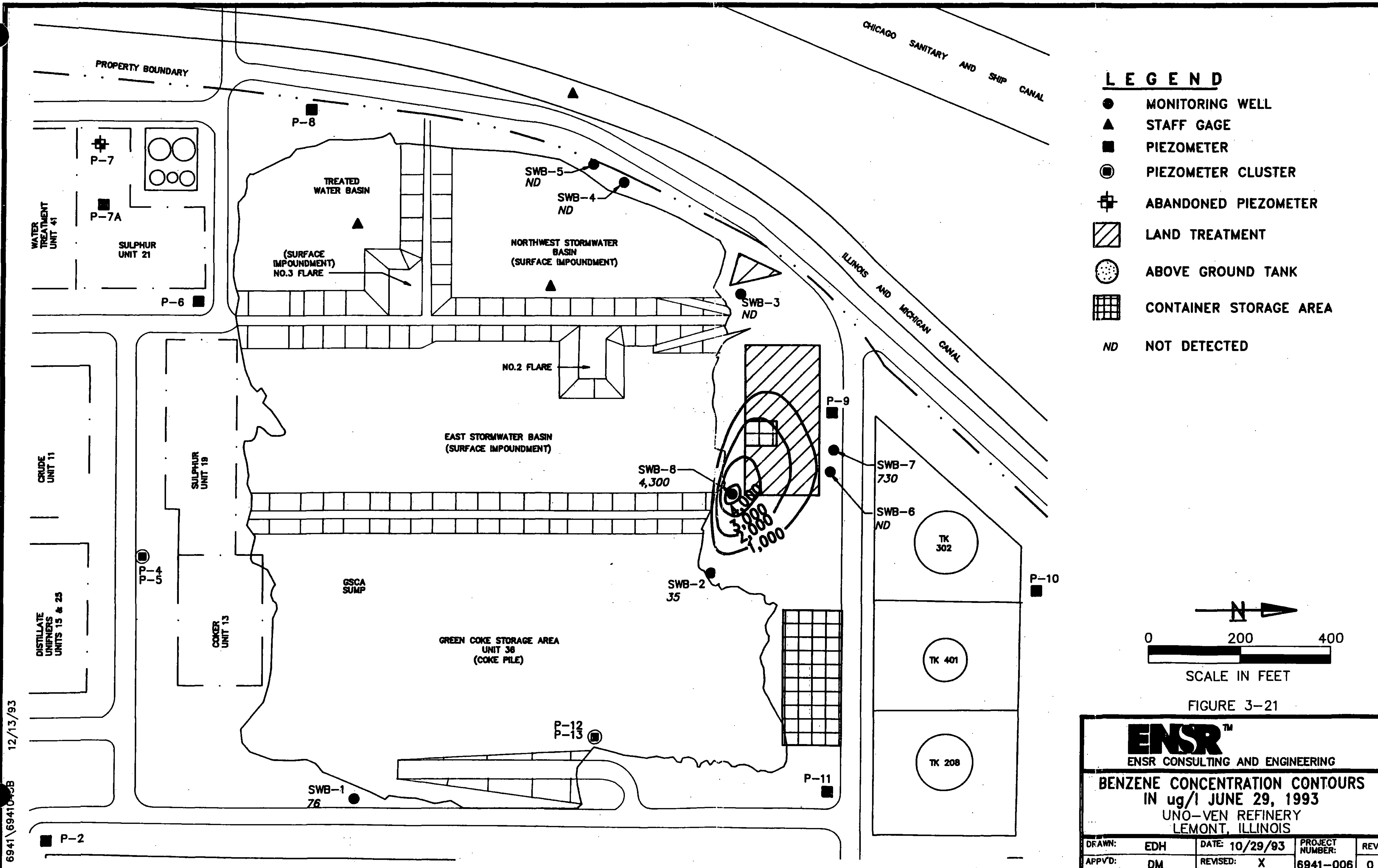


FIGURE 3-21

ENSR™
ENSR CONSULTING AND ENGINEERING

BENZENE CONCENTRATION CONTOURS IN ug/l JUNE 29, 1993
UNO-VEN REFINERY
LEMONT, ILLINOIS

DRAWN:	EDH	DATE:	10/29/93	PROJECT NUMBER:		REV.
APPV'D:	DM	REVISED:	X	6941-006		0

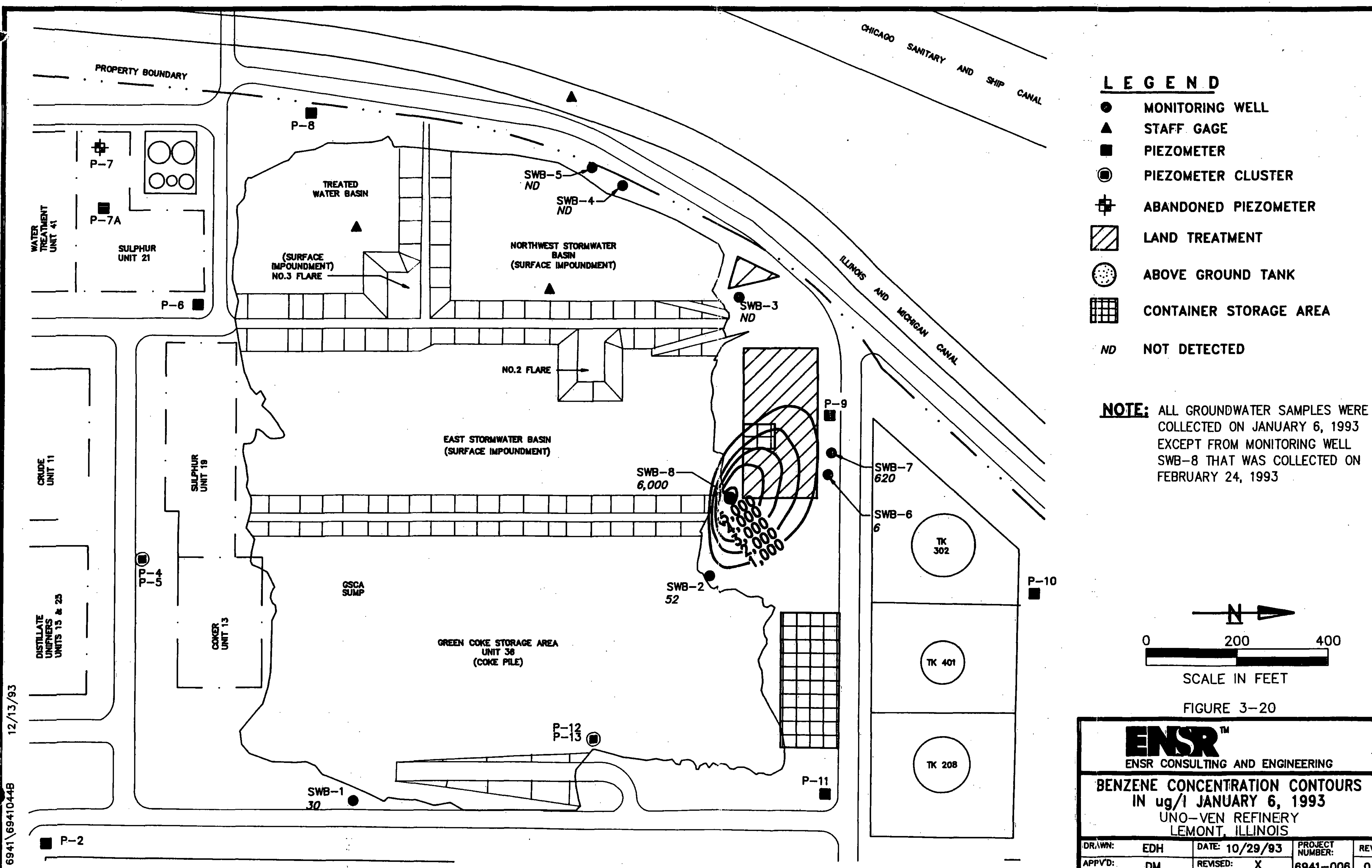


FIGURE 3-20

ENSR CONSULTING AND ENGINEERING

BENZENE CONCENTRATION CONTOURS IN ug/l JANUARY 6, 1993
UNO-VEN REFINERY
LEMONT, ILLINOIS

DRAWN: EDH	DATE: 10/29/93	PROJECT NUMBER:	REV.
APPV'D: DM	REVISED: X	6941-006	0

4.0 SUMMARY AND CONCLUSIONS

From January 1 through November 30, 1993, ENSR implemented a supplemental groundwater investigation at the UNO-VEN refinery as part of the RCRA Alternate Groundwater Monitoring Program. The objectives of the program were: (1) to evaluate the groundwater flow around the SWB, (2) to assess the impact of the SWB on the quality of groundwater directly adjacent to it, and (3) to determine the extent of fracturing and bedrock voids associated with oily residue found in borings immediately north of the east SWB. The following paragraphs present ENSR's summary and conclusions for the supplemental groundwater investigation

4.1 Fractured Bedrock Delineation

Results of the GPR survey conducted north of the east SWB were not conclusive; because conditions were not suitable to identify void spaces within the bedrock, multiple horizontal reflections were not obtained. This may have been the result of increased water content within the rock or the degree of weathering of the bedrock.

Although void spaces were not delineated during the survey, several areas of competent bedrock were tentatively identified. These locations include the area north of SWB-2, previous borings east of the north influent pipe, and newly installed monitoring well location SWB-8. However, GPR reflections at the previous boring locations may be the result of 18 cubic yards of grout pumped into the boreholes.

Monitoring well SWB-8 was installed adjacent to the east SWB, approximately 140 feet west of SWB-2 and 30 feet north of the basin. Bedrock encountered at this location was highly fractured and porous from approximately 3 to 11 feet, becoming less fractured and more competent with depth. Oily sheens and petroleum odors were present in several fractures.

4.2 Bedrock Hydraulic Conductivity

Hydraulic conductivity testing results obtained during the supplemental groundwater investigation and during previous investigations at the UNO-VEN refinery indicate hydraulic conductivity values ranging from 5.7×10^{-3} to 1.4×10^{-5} cm/sec in the shallow screened intervals (from 8 to 28 feet). In the deep screened intervals (43 to 50 feet), hydraulic conductivity values decrease; results vary from 2.4×10^{-5} to 4.8×10^{-9} cm/sec. The difference in values between the shallow and deep screen intervals is likely due to the amount of weathering and fracturing within the bedrock.

4.3 Groundwater Elevation and Flow

Groundwater elevation measurements collected monthly from January to November 1993 and from previous water level monitoring events indicate that water level elevations in wells surrounding the SWBs, TWB, and GCSA sump are generally higher than elevations in these basins, indicating a radial groundwater flow into the SWBs and the GCSA sump.

The results of the supplemental groundwater investigation confirm that the basin and, in particular, the GCSA sump act as local sink or discharge areas. The calculated groundwater velocity toward the east SWB from the area north of the basin is approximately 0.9 ft/day. An outward flow direction along the west portion of the northwest SWB toward the I&M Canal was detected on only one occasion (January 6, 1993), during a high water stage in the basin. Surface water from the TWB is migrating toward the SWBs; water from the SWBs is seeping into the GCSA sump.

4.4 Groundwater Quality

Groundwater samples collected as part of the RCRA Alternate Groundwater Monitoring Program were analyzed for VOCs and SVOCs, indicator parameters (pH, specific conductance, TOC, and TOX), and groundwater quality parameters (chloride, iron, manganese, phenols, sodium, and sulfate).

Analytical results indicate BTEX compounds in all SWB monitoring wells except SWB-3, SWB-4, and SWB-5. The highest concentrations of BTEX are present in monitoring wells SWB-8 and (to a lesser degree) SWB-7. Based on benzene isopleth concentrations, a benzene plume appears to be centered around monitoring well SWB-8. The sludge drying beds or the surrounding areas are assumed to be the source for the BTEX compounds detected in these monitoring wells.

Analytical results indicate that SVOCs are present in monitoring wells SWB-2, SWB-6, SWB-7, and SWB-8. The highest concentrations were detected in SWB-7 and SWB-8. Compounds detected in these wells include phenols, naphthalene, 2-methylnaphthalene, 4-methylphenol, 2-methylphenol, and 3+4-methylphenol; 2-methylnaphthalene was also detected in monitoring SWB-2. Other compounds (2,4-dimethylphenol, 2,4-dichlorophenol, 2,4,5-trichlorophenol, 2,4,6-trichlorophenol, and di-n-butylphthalate) have been detected in monitoring well SWB-6. The source of the these semivolatile organics in monitoring wells north of the east basin is likely the former sludge drying bed area or the tank farm northeast of the former sludge drying beds.

5.0 REFERENCES

ENSR, 1991. *Preliminary Hydrogeologic Assessment - Stormwater Basins* ENSR Document No. 6941-006-300.

ENSR, 1991. *Phase II Hydrogeological Assessment of the Stormwater Basin at UNO-VEN's Chicago Refinery*. ENSR Document No. 6941-006-450.

Hvorslev, M.J., 1951. *Time Lag and Soil Permeability in Groundwater Observations.* Waterways Experiment Station Bulletin No. 36, Vicksburg, Mississippi.

Todd, D.K., 1980. *Groundwater Hydrology.* John Wiley & Sons, New York.

Ulriksen, C.P.F., 1982. *Application of Impulse Radar to Civil Engineering.* GSSI, Salem, New Hampshire, pp. 22-25.

APPENDIX A

BORING LOG FOR MONITORING WELL SWB-8

ROCK CORE LOG

CLIENT : UNO-VEN
PROJECT NAME : Supplemental GW Invest.
PROJECT LOCATION : Uno-Ven Refinery
Lemont, Illinois
PROJECT NUMBER : 6941-006-732

GROUND ELEV. : 586.46
M.P. ELEV. : 588.95

DATE STARTED : 1/28/93
DATE COMPLETED : 1/29/93

TOTAL DEPTH : 20.0 ft
METHOD : Nx/HSA

LOGGED BY : T. Adams
APPROVED BY : J. Starks
DRILLED BY : Fox Drilling Inc.

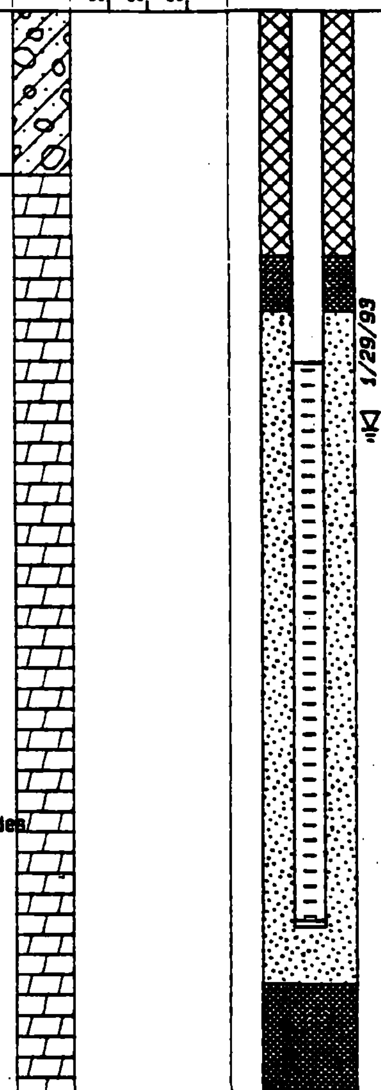
WELL I.D. : 2 in
CASING LENGTH : 9.2 ft
TYPE : 304 SS

SCREEN LENGTH : 10 ft
SLOT SIZE : 0.010 in
TYPE : 304 SS

DEPTH (feet)	RUN NUMBER	RECX/RQDX	DESCRIPTION
0–3			SILT - sandy, some weathered dolomite, drk brown to grey moist
3–20	1	82/38	DOLOMITE - fine-med crystalline, drk grey to black, highly fractured, vuggy, weathered, clay in weathered fractures and vugs, oily residue from 8-9.5 feet, petroleum odor
	2	100/69	- dolomite, as above, white-grey, moderately weathered, grades to moderately competent and less fractured with depth
20			End of boring at 20.0 feet. NX coring to 19 feet. Reamed borehole with 6-1/4 I.D. hollow-stem augers to 20 feet. Installed monitoring well.

Column headings: DEPTH (feet) | RUN NUMBER | LENGTH | RECOVERY | RECX/RQDX | FRACTURES PER FOOT (4, 8) | DESCRIPTION | GRAPHIC LOG | PACKER TEST PERMEABILITY cm/sec (10^{-6} 10^{-5} 10^{-4}) | WELL COMPLETION | DEPTH (feet)

Depth scale: 5, 10, 15, 20, 25



APPENDIX B

HYDRAULIC CONDUCTIVITY TEST DATA

SWB-4 Rising Head Test

SE1000B
Environmental Logger
03/10 09:23

Unit# 00000 Test# 1

INPUT 1: Level (F) TOC

Reference 0.00
Scale factor 20.00
Offset 0.00

Step# 0 02/24 10:28

Elapsed Time	Value
0.0000	30.18
0.0033	30.21
0.0066	30.19
0.0099	30.22
0.0133	30.74
0.0166	29.48
0.0200	30.77
0.0233	30.51
0.0266	30.57
0.0300	30.63
0.0333	30.55
0.0500	30.53
0.0666	30.55
0.0833	30.51
0.1000	30.51
0.1166	30.51
0.1333	30.50
0.1500	30.50
0.1666	30.50
0.1833	30.49
0.2000	30.49
0.2166	30.48
0.2333	30.48
0.2500	30.48
0.2666	30.48
0.2833	30.46
0.3000	30.46
0.3166	30.45
0.3333	30.46
0.4167	30.44
0.5000	30.43
0.5833	30.41
0.6667	30.39
0.7500	30.38
0.8333	30.36
0.9167	30.34
1.0000	30.33
1.0833	30.31
1.1667	30.30
1.2500	30.28
1.3333	30.27
1.4166	30.25
1.5000	30.24
1.5833	30.22
1.6667	30.21
1.7500	30.19
1.8333	30.17
1.9167	30.16
2.0000	30.15
2.5000	30.05
3.0000	29.97
3.5000	29.90
4.0000	29.80

SWB-8 Falling Head Test

SE1000B
Environmental Logger
03/10 09:20

Unit# 00000 Test# 0

INPUT 1: Level (F) TOC

Reference 0.00
Scale factor 20.00
Offset 0.00

Step# 0 02/23 12:09

Elapsed Time	Value
0.0000	-5.97
0.0033	-4.60
0.0066	5.02
0.0099	0.11
0.0133	-1.77
0.0166	0.85
0.0200	0.43
0.0233	-0.90
0.0266	0.26
0.0300	0.32
0.0333	-0.33
0.0500	0.08
0.0666	-0.05
0.0833	-0.01
0.1000	-0.05
0.1166	-0.05
0.1333	-0.05
0.1500	-0.06
0.1666	-0.06
0.1833	-0.07
0.2000	-0.07
0.2166	-0.08
0.2333	-0.08
0.2500	-0.08
0.2666	-0.08
0.2833	-0.08
0.3000	-0.08
0.3166	-0.08
0.3333	-0.08
0.4167	-0.09
0.5000	-0.09
0.5833	-0.10
0.6667	-0.10
0.7500	-0.09
0.8333	-0.09
0.9167	-0.09
1.0000	-0.09
1.0833	-0.09
1.1667	-0.09
1.2500	-0.09
1.3333	-0.09
1.4166	-0.09
1.5000	-0.09
1.5833	-0.09
1.6667	-0.08
1.7500	-0.09
1.8333	-0.08
1.9167	-0.08
2.0000	-0.08
2.5000	-0.08
3.0000	-0.08
3.5000	-0.08
4.0000	-0.08

SWB-8 Rising Head Test

SE1000B
Environmental Logger
03/10 09:22

Unit# 00000 Test# 0

INPUT 1: Level (F) TOC

Reference 0.00
Scale factor 20.00
Offset 0.00

Step# 1 02/23 13:39

Elapsed Time	Value
0.0000	1.51
0.0033	1.23
0.0066	0.95
0.0099	-0.96
0.0133	0.79
0.0166	1.07
0.0200	-0.20
0.0233	0.64
0.0266	0.56
0.0300	0.07
0.0333	0.48
0.0500	0.19
0.0666	0.20
0.0833	0.18
0.1000	0.15
0.1166	0.15
0.1333	0.15
0.1500	0.14
0.1666	0.13
0.1833	0.13
0.2000	0.13
0.2166	0.13
0.2333	0.13
0.2500	0.13
0.2666	0.13
0.2833	0.12
0.3000	0.13
0.3166	0.13
0.3333	0.12
0.4167	0.11
0.5000	0.11
0.5833	0.11
0.6667	0.11
0.7500	0.10
0.8333	0.10
0.9167	0.10
1.0000	0.10
1.0833	0.10
1.1667	0.10
1.2500	0.10
1.3333	0.10
1.4166	0.10
1.5000	0.10
1.5833	0.10
1.6667	0.10
1.7500	0.10
1.8333	0.10
1.9167	0.10
2.0000	0.10
2.5000	0.09
3.0000	0.09
3.5000	0.08
4.0000	0.08

4.5000	29.72
5.0000	29.64
5.5000	29.56
6.0000	29.48
6.5000	29.40
7.0000	29.33
7.5000	29.25
8.0000	29.18
8.5000	29.11
9.0000	29.04
9.5000	28.98
10.0000	28.92
12.0000	28.65
14.0000	28.41
16.0000	28.18
18.0000	27.97
20.0000	27.76
22.0000	27.56
24.0000	27.35
26.0000	27.16
28.0000	26.96
30.0000	26.78
32.0000	26.60
34.0000	26.44
36.0000	26.30
38.0000	26.16
40.0000	26.03
42.0000	25.90
44.0000	25.78
46.0000	25.65
48.0000	25.52
50.0000	25.40
52.0000	25.28
54.0000	25.16
56.0000	25.05
58.0000	24.93
60.0000	24.81
62.0000	24.70
64.0000	24.59
66.0000	24.47
68.0000	24.37
70.0000	24.25
72.0000	24.14
74.0000	24.04
76.0000	23.93
78.0000	23.82
80.0000	23.72
82.0000	23.61
84.0000	23.51
86.0000	23.41
88.0000	23.31
90.0000	23.21
92.0000	23.11
94.0000	23.00
96.0000	22.91
98.0000	22.81
100.000	22.71
110.000	22.24
120.000	21.78
130.000	21.34
140.000	20.86
150.000	20.39
160.000	19.96
170.000	19.54
180.000	19.12
190.000	18.72
200.000	18.32
210.000	17.92
220.000	17.53
230.000	17.14
240.000	16.77

4.5000	−0.07
5.0000	−0.07
5.5000	−0.07
6.0000	−0.07
6.5000	−0.06
7.0000	−0.06
7.5000	−0.06
8.0000	−0.05
8.5000	−0.06
9.0000	−0.06
9.5000	−0.06
10.0000	−0.06
12.0000	−0.06
14.0000	−0.06
16.0000	−0.05
18.0000	−0.05
20.0000	−0.05
22.0000	−0.05
24.0000	−0.05
26.0000	−0.04
28.0000	−0.03
30.0000	−0.04
32.0000	−0.04
34.0000	−0.03
36.0000	−0.03
38.0000	−0.03
40.0000	−0.03
42.0000	−0.03
44.0000	−0.02
46.0000	−0.03
48.0000	−0.03
50.0000	−0.03
52.0000	−0.02
54.0000	−0.02
56.0000	−0.01
58.0000	−0.02
60.0000	−0.02
62.0000	−0.01
64.0000	−0.01
66.0000	−0.01
68.0000	−0.01
70.0000	−0.01
72.0000	−0.01
74.0000	−0.01
76.0000	−0.01
78.0000	−0.01
80.0000	−0.01
82.0000	−0.01
84.0000	−0.01
86.0000	−0.01
88.0000	−0.01

4.5000	0.08
5.0000	0.08
5.5000	0.08
6.0000	0.08
6.5000	0.07
7.0000	0.07
7.5000	0.07
8.0000	0.07
8.5000	0.06
9.0000	0.06
9.5000	0.06
10.0000	0.06
12.0000	0.06
14.0000	0.05
16.0000	0.05
18.0000	0.05
20.0000	0.05
22.0000	0.04
24.0000	0.05
26.0000	0.04
28.0000	0.03
30.0000	0.04
32.0000	0.03
34.0000	0.03
36.0000	0.03
38.0000	0.03
40.0000	0.03
42.0000	0.03
44.0000	0.02
46.0000	0.03
48.0000	0.02
50.0000	0.01
52.0000	0.02
54.0000	0.01
56.0000	0.01
58.0000	0.02
60.0000	0.01
62.0000	0.01
64.0000	0.01
66.0000	0.02
68.0000	0.01
70.0000	0.01
72.0000	0.01
74.0000	0.01
76.0000	0.01
78.0000	0.01
80.0000	0.01
82.0000	0.01
84.0000	0.01
86.0000	0.01
88.0000	0.01
90.0000	0.01
92.0000	0.01
94.0000	0.01

250.000	16.39
260.000	16.02
270.000	15.67
280.000	15.31
290.000	14.97
300.000	14.63
310.000	14.29
320.000	13.97
330.000	13.66
340.000	13.35
350.000	13.04
360.000	12.74
370.000	12.43
380.000	12.14
390.000	11.85
400.000	11.56
410.000	11.28
420.000	11.00
430.000	10.69
440.000	10.42
450.000	10.16
460.000	9.92
470.000	9.68
480.000	9.44
490.000	9.20
500.000	8.98
510.000	8.75
520.000	8.53
530.000	8.31
540.000	8.11
550.000	7.90
560.000	7.70
570.000	7.50
580.000	7.31
590.000	7.12
600.000	6.94
610.000	6.76
620.000	6.58
630.000	6.41
640.000	6.25
650.000	6.08
660.000	5.92
670.000	5.77
680.000	5.61
690.000	5.46
700.000	5.32
710.000	5.17
720.000	5.04
730.000	4.90
740.000	4.77
750.000	4.64
760.000	4.51
770.000	4.39
780.000	4.27
790.000	4.16
800.000	4.04
810.000	3.93
820.000	3.82
830.000	3.72
840.000	3.62
850.000	3.52
860.000	3.43
870.000	3.33
880.000	3.24
890.000	3.15
900.000	3.07
910.000	2.98
920.000	2.90
930.000	2.82
940.000	2.74
950.000	2.67

960.000	2.59
970.000	2.52
980.000	2.45
990.000	2.39
1000.00	2.32
1060.00	1.98
1120.00	1.69
1180.00	1.45
1240.00	1.26
1300.00	1.11
1360.00	0.98
1420.00	0.87
1480.00	0.78
1540.00	0.71
1600.00	0.66
1660.00	0.63
1720.00	0.59
1780.00	0.58
1840.00	0.56
1900.00	0.55
1960.00	0.54
2020.00	0.53
2080.00	0.53
2140.00	0.52
2200.00	0.52
2260.00	0.52
2320.00	0.53
2380.00	0.53
2440.00	0.54
2500.00	0.54
2560.00	0.55
2620.00	0.56
2680.00	0.56
2740.00	0.57
2800.00	0.58

SWB–6 Rising Head Test

SE1000B
Environmental Logger
02/27 10:20

Unit# 25764 Test# 0

INPUT 1: Level (F) TOC

Reference 0.00
Scale factor 20.06
Offset – 0.01

Step# 0 02/27 10:20

Elapsed Time	Value
0	–0.05
240	–0.63
480	–0.64
720	–0.66
960	–0.67
1200	–0.68
1440	–0.7
1680	–0.72
1920	–0.73
2160	–0.76
2400	–0.77
2640	–0.79
7	–0.81
3120	–0.83
3360	–0.86
3600	–0.88
3840	–0.9
4080	–0.92
4320	–0.93
4560	–0.96
4800	–0.98
5040	–0.99
5280	–1
5520	–1.02
5760	–1.05
6000	–1.06
6240	–1.08
6480	–1.11
6720	–1.13
6960	–1.15
7200	–1.17
7440	–1.2
7680	–1.22
7920	–1.24
8160	–1.26
8400	–1.28
8640	–1.31
8880	–1.33
9120	–1.35
9360	–1.38
9600	–1.4
9840	–1.41
10080	–1.43
10320	–1.46
10560	–1.49
10800	–1.51
11040	–1.53
11280	–1.55
11520	–1.58
11760	–1.6
12000	–1.62
12240	–1.64

SWB–7 Falling Head Test

SE1000B
Environmental Logger
02/25 14:27

Unit# 25764 Test# 0

INPUT 1: Level (F) TOC

Reference 0.00
Scale factor 20.06
Offset – 0.01

Step# 0 02/24 09:19

Elapsed Time	Value
0.0000	–0.01
0.0033	–0.00
0.0066	0.00
0.0099	0.00
0.0133	0.00
0.0166	0.01
0.0200	0.00
0.0233	–0.43
0.0266	–0.48
0.0300	–0.01
0.0333	–0.40
0.0500	–0.51
0.0666	–0.89
0.0833	–0.97
0.1000	–0.97
0.1166	–0.97
0.1333	–0.97
0.1500	–0.97
0.1666	–0.97
0.1833	–0.97
0.2000	–0.97
0.2166	–0.96
0.2333	–0.97
0.2500	–1.31
0.2666	0.13
0.2833	–0.73
0.3000	–0.74
0.3166	–1.00
0.3333	–1.01
0.4167	–1.00
0.5000	–1.00
0.5833	–1.00
0.6667	–0.99
0.7500	–0.98
0.8333	–0.98
0.9167	–0.97
1.0000	–0.97
1.0833	–0.97
1.1667	–0.96
1.2500	–0.96
1.3333	–0.95
1.4166	–0.95
1.5000	–0.94
1.5833	–0.93
1.6667	–0.93
1.7500	–0.93
1.8333	–0.93
1.9167	–0.92
2.0000	–0.92
2.5000	–0.90
3.0000	–0.88
3.5000	–0.86

SWB–7 Rising Head Test

SE1000B
Environmental Logger
02/25 14:38

Unit# 25764 Test# 1

INPUT 1: Level (F) TOC

Reference 0.00
Scale factor 20.06
Offset – 0.01

Step# 0 02/24 12:59

Elapsed Time	Value
0.0000	–0.00
0.0033	1.25
0.0066	1.99
0.0099	–0.01
0.0133	0.10
0.0166	1.94
0.0200	1.44
0.0233	0.71
0.0266	1.17
0.0300	1.27
0.0333	1.03
0.0500	1.09
0.0666	1.10
0.0833	1.10
0.1000	1.10
0.1166	1.09
0.1333	1.09
0.1500	1.09
0.1666	1.09
0.1833	1.09
0.2000	1.10
0.2166	1.09
0.2333	1.09
0.2500	1.09
0.2666	1.08
0.2833	1.08
0.3000	1.08
0.3166	1.07
0.3333	1.07
0.4167	1.06
0.5000	1.05
0.5833	1.05
0.6667	1.04
0.7500	1.04
0.8333	1.03
0.9167	1.03
1.0000	1.02
1.0833	1.02
1.1667	1.02
1.2500	1.02
1.3333	1.01
1.4166	1.00
1.5000	1.00
1.5833	1.00
1.6667	1.00
1.7500	0.99
1.8333	0.99
1.9167	0.98
2.0000	0.98
2.5000	0.97
3.0000	0.95
3.5000	0.94

12480	−1.67
12720	−1.69
12960	−1.71
13200	−1.73
13440	−1.75
13680	−1.77
13920	−1.8
14160	−1.82
14400	−1.84
14640	−1.86
14880	−1.89
15120	−1.91
15360	−1.92
15600	−1.95
15840	−1.98
16080	−2
16320	−2.02
16560	−2.05
16800	−2.07
17040	−2.1
17280	−2.12
17520	−2.14
17760	−2.16
18000	−2.19
18240	−2.22
18480	−2.23
18720	−2.26
18960	−2.28
19200	−2.31
19440	−2.33
19680	−2.36
19920	−2.38
20160	−2.4
20400	−2.42
20640	−2.45
20880	−2.47
21120	−2.49
21360	−2.52
21600	−2.54
21840	−2.57
22080	−2.6
22320	−2.63
22560	−2.66
22800	−2.69
23040	−2.71
23280	−2.75
23520	−2.79
23760	−2.81
24000	−2.85
24240	−2.88
24480	−2.9
24720	−2.94
24960	−2.97
25200	−3
25440	−3.03
25680	−3.06
25920	−3.09
26160	−3.13
26400	−3.16
26640	−3.21
26880	−3.27
27120	−3.35
27360	−3.44
27600	−3.53
27840	−3.62
28080	−3.71
28320	−3.79
28560	−3.87
28800	−3.94
29040	−4
29280	−4.06
29520	−4.13

4.0000	−0.84
4.5000	−0.81
5.0000	−0.79
5.5000	−0.78
6.0000	−0.76
6.5000	−0.74
7.0000	−0.72
7.5000	−0.71
8.0000	−0.69
8.5000	−0.68
9.0000	−0.67
9.5000	−0.65
10.0000	−0.64
12.0000	−0.59
14.0000	−0.55
16.0000	−0.52
18.0000	−0.48
20.0000	−0.45
22.0000	−0.43
24.0000	−0.40
26.0000	−0.38
28.0000	−0.36
30.0000	−0.34
32.0000	−0.32
34.0000	−0.31
36.0000	−0.29
38.0000	−0.27
40.0000	−0.26
42.0000	−0.25
44.0000	−0.24
46.0000	−0.23
48.0000	−0.22
50.0000	−0.21
52.0000	−0.19
54.0000	−0.19
56.0000	−0.18
58.0000	−0.17
60.0000	−0.16
62.0000	−0.16
64.0000	−0.15
66.0000	−0.15
68.0000	−0.14
70.0000	−0.13
72.0000	−0.13
74.0000	−0.13
76.0000	−0.12
78.0000	−0.12
80.0000	−0.11
82.0000	−0.10
84.0000	−0.10
86.0000	−0.10
88.0000	−0.09
90.0000	−0.09
92.0000	−0.08
94.0000	−0.08
96.0000	−0.08
98.0000	−0.08
100.000	−0.08
110.000	−0.06
120.000	−0.05
130.000	−0.04
140.000	−0.03
150.000	−0.03
160.000	−0.02
170.000	−0.02
180.000	−0.01
190.000	−0.01
200.000	−0.01
210.000	−0.01

4.0000	0.93
4.5000	0.91
5.0000	0.91
5.5000	0.90
6.0000	0.89
6.5000	0.88
7.0000	0.87
7.5000	0.86
8.0000	0.85
8.5000	0.84
9.0000	0.83
9.5000	0.82
10.0000	0.81
12.0000	0.78
14.0000	0.75
16.0000	0.72
18.0000	0.70
20.0000	0.67
22.0000	0.65
24.0000	0.62
26.0000	0.60
28.0000	0.58
30.0000	0.57
32.0000	0.55
34.0000	0.53
36.0000	0.51
38.0000	0.50
40.0000	0.48
42.0000	0.46
44.0000	0.45
46.0000	0.44
48.0000	0.43
50.0000	0.41
52.0000	0.40
54.0000	0.39
56.0000	0.38
58.0000	0.37
60.0000	0.36
62.0000	0.34
64.0000	0.34
66.0000	0.32
68.0000	0.32
70.0000	0.32
72.0000	0.30
74.0000	0.29
76.0000	0.28
78.0000	0.27
80.0000	0.26
82.0000	0.26
84.0000	0.26
86.0000	0.25
88.0000	0.24
90.0000	0.24
92.0000	0.23
94.0000	0.22
96.0000	0.22
98.0000	0.21
100.000	0.20
110.000	0.19
120.000	0.16
130.000	0.15
140.000	0.12
150.000	0.12
160.000	0.11
170.000	0.10
180.000	0.08
190.000	0.08
200.000	0.07
210.000	0.07
220.000	0.06
230.000	0.06
240.000	0.05

29760	−4.18
30000	−4.23
30240	−4.3
30480	−4.35
30720	−4.42
30960	−4.48
31200	−4.54
31440	−4.59
31680	−4.66
31920	−4.71
32160	−4.78
32400	−4.84
32640	−4.89
32880	−4.95
33120	−5.02
33360	−5.07
33600	−5.14
33840	−5.21
34080	−5.27
34320	−5.33
34560	−5.4
34800	−5.48
35040	−5.55
35280	−5.62
35520	−5.68
35760	−5.75
36000	−5.82
36240	−5.89
36480	−5.94
36720	−6.01
36960	−6.06
37200	−6.13
37440	−6.19
37680	−6.26
37920	−6.32
38160	−6.39
38400	−6.45
38640	−6.51
38880	−6.59
39120	−6.66
39360	−6.72
39600	−6.79
39840	−6.86
40080	−6.93
40320	−7
40560	−7.06
40800	−7.13
41040	−7.18
41280	−7.24
41520	−7.3
41760	−7.37
42000	−7.42
42240	−7.48
42480	−7.54
42720	−7.59
42960	−7.64
43200	−7.7
43440	−7.77
43680	−7.83
43920	−7.92
44160	−7.99
44400	−8.04
44640	−8.08
44880	−8.12
45120	−8.18
45360	−8.22
45600	−8.27
45840	−8.32

250.000	0.05
260.000	0.05
270.000	0.05
280.000	0.04
290.000	0.05
300.000	0.04
310.000	0.04
320.000	0.04
330.000	0.04
340.000	0.04
350.000	0.04
360.000	0.04
370.000	0.04
380.000	0.05
390.000	0.04
400.000	0.04
410.000	0.04
420.000	0.04
430.000	0.03
440.000	0.03
450.000	0.03
460.000	0.03
470.000	0.04
480.000	0.04
490.000	0.04
500.000	0.04
510.000	0.04
520.000	0.04
530.000	0.04
540.000	0.04
550.000	0.04
560.000	0.05
570.000	0.05
580.000	0.05
590.000	0.05
600.000	0.05
610.000	0.05
620.000	0.05
630.000	0.05
640.000	0.05
650.000	0.05
660.000	0.05
670.000	0.05
680.000	0.05
690.000	0.05
700.000	0.05
710.000	0.05
720.000	0.05
730.000	0.05
740.000	0.05
750.000	0.04
760.000	0.04
770.000	0.03
780.000	0.04
790.000	0.03
800.000	0.03
810.000	0.03
820.000	0.03
830.000	0.02
840.000	0.02
850.000	0.02
860.000	0.01
870.000	0.01
880.000	0.01
890.000	0.01
900.000	0.01
910.000	0.01
920.000	0.00
930.000	0.00
940.000	0.00
950.000	0.00
960.000	0.00

970.000	0.00
980.000	0.00
990.000	0.00
1000.00	0.00
1010.00	0.00
1020.00	0.00
1030.00	0.00
1040.00	0.00
1050.00	0.00
1060.00	−0.00
1070.00	−0.00
1080.00	0.00
1090.00	−0.00
1100.00	−0.00
1110.00	−0.00
1120.00	−0.00
1130.00	−0.00
1140.00	−0.00
1150.00	−0.00
1160.00	−0.00
1170.00	−0.01

P-5 Falling Head Test
SE1000B
Environmental Logger
02/27 11:39

Unit# 25764 Test# 2

INPUT 1: Level (F) TOC

Reference 0.00
Scale factor 20.06
Offset - 0.01

Step# 0 02/26 10:47

Elapsed Time	Value
0.0000	−0.42
0.0033	−0.27
0.0066	−1.13
0.0099	−1.13
0.0133	−1.96
0.0166	−1.31
0.0200	−0.65
0.0233	−1.42
0.0266	−1.40
0.0300	−2.43
0.0333	−3.48
0.0500	−5.75
0.0666	−5.19
0.0833	−5.64
0.1000	−5.53
0.1166	−5.48
0.1333	−5.89
0.1500	−6.80
0.1666	−6.80
0.1833	−6.90
0.2000	−6.89
0.2166	−6.87
0.2333	−6.87
0.2500	−6.85
0.2666	−6.84
0.2833	−6.83
0.3000	−6.82
0.3166	−6.81
0.3333	−6.80
0.4167	−6.75
0.5000	−7.11
0.5833	−8.38
0.6667	−8.31
0.7500	−8.24
0.8333	−8.17
0.9167	−8.11
1.0000	−8.04
1.0833	−7.98
1.1667	−7.91
1.2500	−7.86
1.3333	−7.80
1.4166	−7.75
1.5000	−7.70
1.5833	−7.64
1.6667	−7.58
1.7500	−7.53
1.8333	−7.48
1.9167	−7.42
2.0000	−7.37
2.5000	−7.09
3.0000	−6.82
3.5000	−6.56
4.0000	−6.31
4.5000	−6.07

P-13 Falling Head Test
SE1000B
Environmental Logger
03/10 09:27

Unit# 00000 Test# 2

INPUT 1: Level (F) TOC

Reference 0.00
Scale factor 20.00
Offset 0.00

Step# 0 03/01 15:54

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0.0066	−0.01
0.0099	−0.01
0.0133	−0.00
0.0166	−0.01
0.0200	−0.00
0.0233	−0.01
0.0266	−0.01
0.0300	−0.06
0.0333	−0.01
0.0500	−0.02
0.0666	−0.69
0.0833	−2.06
0.1000	−5.01
0.1166	−5.76
0.1333	−6.93
0.1500	−8.41
0.1666	−9.73
0.1833	−11.19
0.2000	−11.90
0.2166	−10.74
0.2333	−9.78
0.2500	−10.11
0.2666	−10.64
0.2833	−11.93
0.3000	−12.15
0.3166	−12.17
0.3333	−12.29
0.4167	−15.55
0.5000	−22.13
0.5833	−25.99
0.6667	−25.64
0.7500	−25.54
0.8333	−25.46
0.9167	−25.50
1.0000	−25.42
1.0833	−25.33
1.1667	−25.25
1.2500	−25.20
1.3333	−25.13
1.4166	−25.08
1.5000	−25.03
1.5833	−24.98
1.6667	−24.94
1.7500	−24.91
1.8333	−24.88
1.9167	−24.84
2.0000	−24.81
2.5000	−24.66
3.0000	−24.55
3.5000	−24.48
4.0000	−24.42
4.5000	−24.36

5.0000	−5.84
5.5000	−5.64
6.0000	−5.43
6.5000	−5.24
7.0000	−5.05
7.5000	−4.87
8.0000	−4.70
8.5000	−4.53
9.0000	−4.37
9.5000	−4.22
10.0000	−4.07
12.0000	−3.52
14.0000	−3.06
16.0000	−2.67
18.0000	−2.32
20.0000	−2.04
22.0000	−1.78
24.0000	−1.57
26.0000	−1.37
28.0000	−1.20
30.0000	−1.05
32.0000	−0.93
34.0000	−0.82
36.0000	−0.72
38.0000	−0.64
40.0000	−0.57
42.0000	−0.50
44.0000	−0.45
46.0000	−0.39
48.0000	−0.35
50.0000	−0.31
52.0000	−0.28
54.0000	−0.26
56.0000	−0.22
58.0000	−0.20
60.0000	−0.18
62.0000	−0.16
64.0000	−0.15
66.0000	−0.13
68.0000	−0.12
70.0000	−0.11
72.0000	−0.10
74.0000	−0.09
76.0000	−0.08
78.0000	−0.08
80.0000	−0.06
82.0000	−0.06
84.0000	−0.05
86.0000	−0.05
88.0000	−0.05
90.0000	−0.05
92.0000	−0.05
94.0000	−0.04
96.0000	−0.04
98.0000	−0.04
100.000	−0.03
110.000	−0.03
120.000	−0.01
130.000	−0.01
140.000	−0.01
150.000	−0.01
160.000	−0.01
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180.000	−0.01
190.000	−0.01
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210.000	−0.01
220.000	−0.00
230.000	−0.00
240.000	0.00
250.000	0.00

5.0000	−24.31
5.5000	−24.25
6.0000	−24.20
6.5000	−24.15
7.0000	−24.10
7.5000	−24.07
8.0000	−24.03
8.5000	−23.99
9.0000	−23.96
9.5000	−23.94
10.0000	−23.92
12.0000	−23.84
14.0000	−23.78
16.0000	−23.72
18.0000	−23.67
20.0000	−23.63
22.0000	−23.58
24.0000	−23.55
26.0000	−23.50
28.0000	−23.46
30.0000	−23.43
32.0000	−23.39
34.0000	−23.36
36.0000	−23.32
38.0000	−23.29
40.0000	−23.26
42.0000	−23.23
44.0000	−23.20
46.0000	−23.17
48.0000	−23.14
50.0000	−23.11
52.0000	−23.08
54.0000	−23.05
56.0000	−23.02
58.0000	−23.00
60.0000	−22.97
62.0000	−22.95
64.0000	−22.91
66.0000	−22.89
68.0000	−22.86
70.0000	−22.85
72.0000	−22.82
74.0000	−22.79
76.0000	−22.77
78.0000	−22.74
80.0000	−22.72
82.0000	−22.70
84.0000	−22.68
86.0000	−22.65
88.0000	−22.63
90.0000	−22.61
92.0000	−22.58
94.0000	−22.56
96.0000	−22.52
98.0000	−22.49
100.000	−22.46
110.000	−22.34
120.000	−22.23
130.000	−22.12
140.000	−22.02
150.000	−21.91
160.000	−21.81
170.000	−21.72
180.000	−21.62
190.000	−21.52
200.000	−21.43
210.000	−21.33
220.000	−21.24
230.000	−21.15
240.000	−21.06
250.000	−20.98

260.000	0.00
270.000	0.00
270.000	15.67
280.000	15.31
290.000	14.97
300.000	14.63
310.000	14.29
320.000	13.97
330.000	13.66
340.000	13.35
350.000	13.04
360.000	12.74
370.000	12.43
380.000	12.14
390.000	11.85
400.000	11.56
410.000	11.28
420.000	11.00
430.000	10.69
440.000	10.42
450.000	10.16
460.000	9.92
470.000	9.68
480.000	9.44
490.000	9.20
500.000	8.98
510.000	8.75
520.000	8.53
530.000	8.31
540.000	8.11
550.000	7.90
560.000	7.70
570.000	7.50
580.000	7.31
590.000	7.12
600.000	6.94
610.000	6.76
620.000	6.58
630.000	6.41
640.000	6.25
650.000	6.08
660.000	5.92
670.000	5.77
680.000	5.61
690.000	5.46
700.000	5.32
710.000	5.17
720.000	5.04
730.000	4.90
740.000	4.77
750.000	4.64
760.000	4.51
770.000	4.39
780.000	4.27
790.000	4.16
800.000	4.04
810.000	3.93
820.000	3.82
830.000	3.72
840.000	3.62
850.000	3.52
860.000	3.43
870.000	3.33
880.000	3.24
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900.000	3.07
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920.000	2.90
930.000	2.82
940.000	2.74
950.000	2.67

260.000	−20.89
270.000	−20.81
280.000	−20.72
290.000	−20.64
300.000	−20.56
310.000	−20.48
320.000	−20.40
330.000	−20.32
340.000	−20.24
350.000	−20.16
360.000	−20.08
370.000	−20.01
380.000	−19.93
390.000	−19.86
400.000	−19.78
410.000	−19.70
420.000	−19.63
430.000	−19.56
440.000	−19.48
450.000	−19.41
460.000	−19.34
470.000	−19.28
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500.000	−19.07
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570.000	−18.59
580.000	−18.53
590.000	−18.46
600.000	−18.40
610.000	−18.33
620.000	−18.27
630.000	−18.20
640.000	−18.14
650.000	−18.08
660.000	−18.01
670.000	−17.96
680.000	−17.89
690.000	−17.83
700.000	−17.77
710.000	−17.71
720.000	−17.65
730.000	−17.59
740.000	−17.53
750.000	−17.47
760.000	−17.41
770.000	−17.35
780.000	−17.30
790.000	−17.24
800.000	−17.18
810.000	−17.11
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830.000	−17.00
840.000	−16.94
850.000	−16.89
860.000	−16.83
870.000	−16.78
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900.000	−16.61
910.000	−16.56
920.000	−16.50
930.000	−16.44
940.000	−16.39
950.000	−16.34
960.000	−16.29

960.000	2.59
970.000	2.52
980.000	2.45
990.000	2.39
1000.00	2.32
1060.00	1.98
1120.00	1.69
1180.00	1.45
1240.00	1.26
1300.00	1.11
1360.00	0.98
1420.00	0.87
1480.00	0.78
1540.00	0.71
1600.00	0.66
1660.00	0.63
1720.00	0.59
1780.00	0.58
1840.00	0.56
1900.00	0.55
1960.00	0.54
2020.00	0.53
2080.00	0.53
2140.00	0.52
2200.00	0.52
2260.00	0.52
2320.00	0.53
2380.00	0.53
2440.00	0.54
2500.00	0.54
2560.00	0.55
2620.00	0.56
2680.00	0.56
2740.00	0.57
2800.00	0.58

970.000	−16.23
980.000	−16.18
990.000	−16.13
1000.00	−16.07
1060.00	−15.76
1120.00	−15.46
1180.00	−15.16
1240.00	−14.88
1300.00	−14.60
1360.00	−14.33
1420.00	−14.07
1480.00	−13.81
1540.00	−13.56
1600.00	−13.32
1660.00	−13.08
1720.00	−12.84
1780.00	−12.62
1840.00	−12.39
1900.00	−12.17
1960.00	−11.97
2020.00	−11.76
2080.00	−11.56
2140.00	−11.35
2200.00	−11.16
2260.00	−10.98
2320.00	−10.79
2380.00	−10.61
2440.00	−10.43
2500.00	−10.26
2560.00	−10.09
2620.00	−9.92
2680.00	−9.76
2740.00	−9.60
2800.00	−9.45
2860.00	−9.30

UNO-VEN Refinery

Lemont, Illinois

ENSR

Supplemental Groundwater Investigation Work Plan - RCRA Alternate Groundwater Monitoring Program for the Stormwater Basin

ENSR Consulting and Engineering

December 1992

Document Number 6941-006-720

79

UNO-VEN Refinery

Lemont, Illinois

Supplemental Groundwater Investigation Work Plan - RCRA Alternate Groundwater Monitoring Program for the Stormwater Basin

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CONTENTS

LIST OF FIGURES

1.0 INTRODUCTION

This Work Plan outlines the scope of work, procedures and equipment, and laboratory analytical methods for a supplemental groundwater investigation to be performed along the northeastern embankment of the east stormwater basin at UNO-VEN's refinery in Lemont, Illinois. The investigation is being conducted as part of the RCRA Alternate Groundwater Monitoring Program for the Stormwater Basin; the program was conditionally approved by U.S. EPA on May 22, 1992.

The scope of the proposed groundwater investigation was discussed on November 5, 1992, during a meeting between UNO-VEN, ENSR, and U.S. EPA representatives. The purpose of the investigation is to evaluate the groundwater flow around the stormwater basins, in particular the north side of the east basin, and to assess the impact the basin may have on the quality of groundwater directly adjacent to it. The investigation will also further estimate the extent of the oily residue found in the rock borings advanced immediately north of the east basin.

In order to achieve these objectives, the following investigative program has been developed.

- Conduct a geophysical survey using ground-penetrating radar
- Install a 2-inch-diameter, stainless steel, shallow monitoring well
- Install temporary borehole casing to collect a grab groundwater sample (conditional)
- Survey monitoring wells
- Measure water levels
- Sample groundwater
- Conduct hydraulic conductivity tests

This work plan provides a detailed description of the scope of work for this program, which is to be implemented as soon as practical following U.S. EPA approval.

2.0 FIELD ACTIVITIES

2.1 Geophysical Survey

ENSR will use the ground-penetrating radar (GPR) method to map void spaces within the dolomitic bedrock underlying the northeast edge of the east stormwater basin (Figure 2-1). A GSSI SIR-3 with either a 300- or 55-MHz antenna will be used to acquire continuous GPR data. Data will initially be obtained along a coarse grid of perpendicular lines placed 10 to 20 feet apart. After ENSR has examined the initial data set, we will determine whether additional GPR surveying is required to more accurately define void spaces in the bedrock. If additional data are needed, a finer grid of perpendicular lines, possibly 2 to 5 feet apart, will be used.

Results of the GPR survey will help determine the location for an additional monitoring well; the results will be used to avoid placing the well in a void space area.

2.2 Monitoring Well Drilling

One shallow monitoring well, designated as SWB-8, will be installed into bedrock in the vicinity of the northeast corner of the east stormwater basin (Figure 2-1). If void spaces are encountered during drilling in this area, the monitoring well will not be installed. Instead, a rock core boring will be drilled in the area north of the east basin where oily residue was found previously. Temporary casing will be placed in the core hole and a grab groundwater sample will be collected.

If a well can be installed in the bedrock, a boring will be advanced to an approximate depth of 15 to 20 feet. Current knowledge of the area indicates that dolomitic bedrock is within 5 feet of the surface; surface materials comprise non-native fill, rubble, roadway, etc. The fill and bedrock materials will be drilled by coring, if possible, to the desired depth. Rock coring will be performed in accordance with ENSR's Standard Operating Procedure (SOP) Number 2210 (Appendix A). If coring of the fill material is not possible, solid-stem augers will be advanced through the surface materials to the bedrock surface.

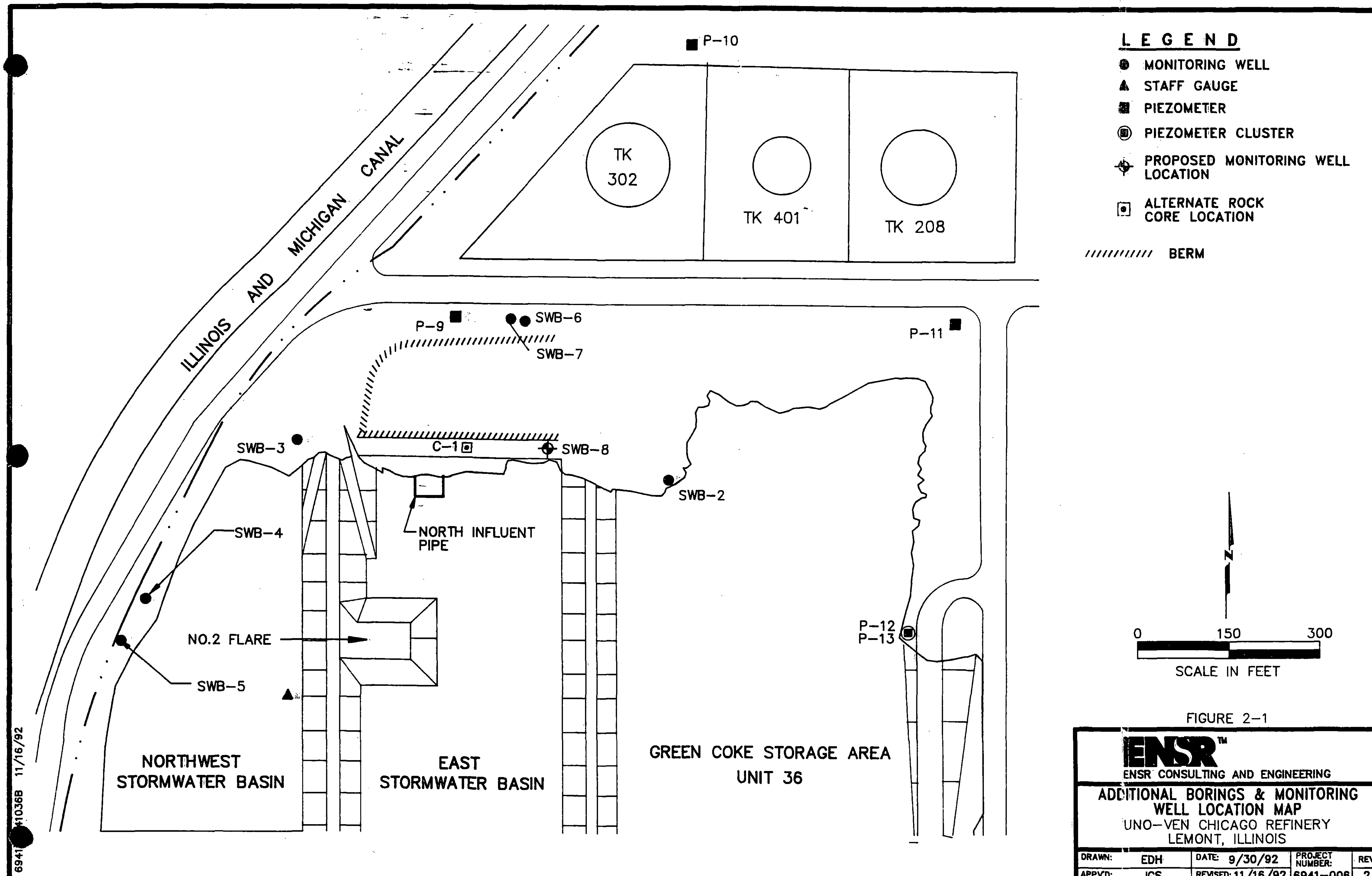

FIGURE 2-1

ENSR CONSULTING AND ENGINEERING

ADDITIONAL BORINGS & MONITORING WELL LOCATION MAP
UNO-VEN CHICAGO REFINERY
LEMONT, ILLINOIS

DRAWN:	EDH	DATE: 9/30/92	PROJECT NUMBER:	REV.
APPV'D:	JCS	REVISED: 11/16/92	6941-006	2

Coring will be performed in 10-foot runs, as appropriate, utilizing an NX-size core bit and barrel (borehole diameter approximately 3 inches). Potable water may be injected into the borehole to facilitate coring. Rock cores will be logged by the supervising geologist on standard coring logs and the cores will be placed in labeled core boxes, which will be kept at the site in a location approved by UNO-VEN.

After completion of the rock coring, the borehole will be enlarged by the rotary drilling method using a tri-cone drill bit. The enlarged borehole will be approximately 6 inches. The sequence of drilling locations and methods will be determined based upon conditions encountered at the site.

The borehole will then be flushed with potable water to remove cuttings that may have invaded the adjacent natural formation. Following flushing, the water used to flush the borehole will be evacuated to ensure representative groundwater.

2.3 Well Installation

The static water level in the boring will be determined by the supervising geologist. The boring may need to be left undisturbed for a short time (possibly overnight) to allow the static water level to stabilize. Based on the static water level, the borehole depth may need to be adjusted by further drilling or by filling in the bottom of the borehole with bentonite to ensure that the screen will intersect the water table. The final adjusted borehole depth will be approximately 8 feet below the static water level.

The monitoring well will be installed in accordance with ENSR SOP 7220 (Appendix A). A 10-foot-long, stainless steel, slot size 0.010-inch well screen, and flush-thread jointed riser will be placed approximately 1 foot above the bottom of the borehole so that approximately 3 feet of well screen is situated above the water table. The bottom of the borehole and the annular space around the well screen will be sandpacked to approximately 2 feet above the screen. A 2-foot bentonite seal consisting of bentonite pellets will be installed above the sandpack. The bentonite pellets will be hydrated with potable water and allowed to set before placement of the grout.

A cement-bentonite grout (approximately 95% cement and 5% bentonite by weight) will be pumped by gravity through a tremie pipe or hose to fill the remaining annular space between the riser and the borehole. A locking protective steel well cover, to protect the well riser and to prevent surface water from entering the well, will be anchored with portland cement around the well riser. Two steel bumper posts will be set in the concrete around the well to protect the monitoring well from moving vehicles. A final, as-built well construction diagram will be prepared by the supervising geologist.

Following installation of SWB-8, the monitoring well will be surveyed so that accurate water level elevations may be obtained.

2.4 Well Development

The wells will be developed by bailing with a decontaminated stainless steel bailer or by using compressed gas in accordance with ENSR SOP 7221 (Appendix A). Decontamination procedures involve washing the bailer in a solution of Alconox™ detergent and potable water or distilled water, and rinsing with distilled water (see ENSR SOP 7600 in Appendix A). A minimum of 10 well casing volumes will be removed from each well. The groundwater will be monitored after each well volume removed for pH, temperature, and specific conductivity. After 10 well volumes have been removed and at least three stable parameter measurements have been obtained, the well will be considered developed.

2.5 Water Level Monitoring

Water level monitoring of SWB-8 will be conducted concurrently with the ongoing RCRA Alternate Groundwater Monitoring Program. Water levels will be measured at SWB-8 and at all stormwater basin monitoring wells, piezometers, and staff gauges on a monthly basis or following a high-water event. Water level monitoring will be used to determine the hydrologic relationship of the stormwater basins and the adjacent surface water body (I&M Canal) to the underlying bedrock aquifer in the vicinity of the basins. The water level data will be recorded and input into a database. Water level measurements will be used to generate a water table contour map, determine the groundwater flow direction and horizontal gradient, and estimate the vertical hydraulic gradient.

2.6 Groundwater Sampling

Groundwater sampling at monitoring well SWB-8 will be conducted concurrently with the ongoing RCRA Alternate Groundwater Monitoring Program or following a significant precipitation event when the stormwater basins are at a high-water stage. UNO-VEN will notify ENSR when this occurs so that ENSR can mobilize to the site for sampling. Samples will be analyzed for volatile organic compounds (Method 8240), semivolatile organic compounds (Method 8270), quality parameters (chloride, iron, manganese, phenols, sodium, and sulfates), and indicator parameters (pH, specific conductance, total organic carbon, and total organic halogens) according to the schedule outlined in the May 22, 1992, U.S. EPA letter.

Groundwater samples will be collected from each monitoring well using procedures outlined in ENSR SOP 7130 (Appendix A). The samples will be stored on ice or refrigerated at 4°C from the time of collection until laboratory analysis. Samples will be protected from breakage and shipped in coolers containing ice or other similar agents, in accordance with ENSR SOP 7510 (Appendix A). The pH and specific conductance parameters will be measured in the field.

2.7 Hydraulic Conductivity Testing

Hydraulic conductivity testing, consisting of falling head and rising head tests, will be performed on shallow monitoring well SWB-7 and proposed well SWB-8. The testing will be conducted by displacing groundwater in the well using a slug of known volume. Prior to placement of the slug, a reference static water level will be obtained and recorded in a field notebook. The water level in the well will be monitored as it falls. After the water level has stabilized, the slug will be removed and the change in water level in the well will be monitored as it rises to the static water level. Water level measurements will be taken at successive 5- to 10-second intervals.

Hydraulic conductivity testing will also be performed, following completion of the second quarterly groundwater sampling event, on deep piezometers P-5 and P-13 and deep stormwater basin monitoring wells SWB-4 and SWB-6 using a rising head test. The test will be conducted without a slug by evacuating all of the water inside the well using either a submersible pump or a hand pump. The water will be transferred into a container of known volume. Water level measurements will be taken at successive 5- to 10-second intervals in the beginning of the test and will increase according to a logarithmic scale. Measurements will continue until static water conditions are observed, but not exceeding one month.

During the hydraulic conductivity testing, time/recovery data will be collected using an In-Situ® data logging system consisting of a 10- to 20-psig pressure transducer coupled with a Hermit®

Model SEI000B or equivalent. If required by UNO-VEN, the data logger will be placed in special holding boxes for security. Upon completion of testing, time/recovery data from each falling head and rising head test will be downloaded into a computer and placed in separate files. Calculations of hydraulic conductivity will then be made using the Bouwer & Rice (1976)[1] method or Hvorslev (1951)[2] method. Calculations of hydraulic conductivity will be performed in accordance with ENSR SOP 1005 (Appendix A). The hydraulic conductivity will be used to calculate groundwater velocity in the area north of the east basin, and to estimate the travel time of potential contaminants between this area and the basin.

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[1]Bouwer, H. and R.C. Rice, 1976. *A Slug Test Method for Determining Hydraulic Conductivity Aquifers With Completely or Partially Penetrating Wells.* Water Resources Research, Vol. 12, No. 3, pp. 423-428.

[2]Hvorslev, M.J. 1951. *Time Lag and Soil Permeability in Ground Water Observation.* Waterways Experiment Station Bulletin No. 36, Vicksburg, Mississippi.

3.0 REPORTING

A report documenting the geophysical and well installation activities will be prepared and submitted to UNO-VEN upon completion of these tasks. A separate report documenting quarterly water level measurement data will be submitted with the report for the RCRA Alternate Groundwater Monitoring Program. The geophysical survey, well installation, hydraulic conductivity testing, and water level measurement data will be incorporated into the *RCRA Alternate Monitoring Program Annual Report* in accordance with 40 CFR 265.94(b)(2). The annual report will include a detailed evaluation of the groundwater flow around the stormwater basins, and the impact of the basins on groundwater quality directly adjacent to the basins. The potential for variations in the normal groundwater flow direction and, in particular, for northward groundwater flow from the east basin during high water events will be assessed. Also the extent of the oily residue along the northern boundary of the east basin will be evaluated and potential sources of the oil will be examined.

APPENDIX A

ENSR STANDARD OPERATING PROCEDURES

ENSR

STANDARD OPERATING PROCEDURE

Number: 1005 Date of Issue: 2nd Qtr. 1989

Title: Numerical Analysis and Peer Review

Organizational Acceptance	Authorization	Date
Originator	Scott M. Whittemore	10-31-85
Department Manager	[illegible]	[illegible]
Divisional Manager	Peter Shanahan	Oct 31 1985
Group Quality Assurance Officer	Scott M. Whittemore	10-31-85
Other		

Revisions	Changes	Authorization	Date
1	Title : ● Changed Number from 2005 to 1005	Scott M. Whittemore	5-9-89

ENSR Consulting & Engineering

1283a (12/78)

Title: Numerical Analysis and Peer Review

Number: 1005
Revision: 1

1. Purpose and Applicability

This document describes ENSR's procedure for ensuring that all data analyses for site investigations and other studies are correct and consistent with project objectives and are legibly and retrievably documented. The purpose of the documentation is to permit peer review and reconstruction of the logic by which any conclusions were deduced.

2. Responsibilities

The responsibility for implementation of this procedure on each project rests with the person performing the calculations.

The project manager is responsible for ensuring the completeness of project files.

3. Method of Documentation

3.1 Manual Calculations

3.1.1 All calculations shall be documented in legible, reproduction-quality records. The records shall be complete enough to permit logical reconstruction by a qualified person other than the originator.

3.1.2 Calculations should be maintained in division files during the project, and shall be placed into the central project file at the end of the project.

3.1.3 Each calculation should be assigned a unique identification number by an appropriate person. The calculations may be consecutively numbered within a given project. (e.g., D010-1, D010-2,...).

3.1.4 Calculations for each project should be kept in a binder with an index sheet.

3.1.5 Records of calculations shall contain, on each page, the initials of the originator and reviewer, the date, the project number, calculation number and page number.

3.1.6 Each calculation shall have a cover page which should contain:

- o client name,
- o project name and number,
- o calculation name and number,
- o total number of pages in the calculation,
- o date,
- o originator's signature.

3.1.7 The complete record of any series of calculations for a project shall have a cover page containing at least the following:

- o Statement of purpose
- o Brief description of method
- o Assumptions and justifications
- o Reference to input data sources
- o All numerical calculations, showing all units
- o Results
- o Reference to associated computer output
- o Signature of originator and date

3.2 Computer Programs

Documentation and qualification procedures for ENSR-written computer programs are detailed in ENSR SOP 1006. Each revision of each program is documented in an annotated hard copy of the software. Annotations should be sufficient to permit a qualified individual other than the originator to understand how the program works. Minimum contents of such a record are:

- o Program name
- o Originator's name
- o Input parameters
- o Date of printout
- o Revision number
- o Each page should be numbered, and should indicate the total number of pages in the record

These records are archived along with the qualification records in a central file.

3.3 Computer Program Output

3.3.1 All final computer program output used in a given project will be retained in hard copy in the project files. The output should be bound and assigned a unique reference number.

3.3.2 Each program output record shall contain at least the following:

- o Name and revision date of program or model used
- o Input parameters
- o Name of user
- o Date of run

3.4 Drawings

3.4.1 All drawings shall be labeled with a unique identification number, which might consist of the project number and a sequential drawing number (e.g. D010-1, D010-2,...).

3.4.2 All drawings shall be constructed using standardized symbols and nationally-recognized drafting standards

3.4.3 All drawings shall be signed and dated by the originator and checked, signed and dated by a reviewer.

3.4.4 All drawings to be published must be approved for issue by the project manager or his designee.

4. Method for Review and Revision

4.1 All calculations and drawings for each project shall be verified by a qualified person other than the originator.

4.2 Verification shall consist of a thorough check of the calculations for the following elements:

- **o Appropriateness of method,**
- **o Appropriateness of assumptions,**
- **o Correctness of calculations,**
- **o Completeness of references,**
- **o Completeness of record.**
- **o Correctness of input parameters for calculations using computer programs.**

4.3 Method of Review - It is the responsibility of the reviewer to assure that the methodology used and results obtained are correct. This may require verification of each number in the calculation, but this is usually not necessary. Typically, spot checks of the computations and visual inspection for the reasonableness constitute a sufficiently thorough check.

In some cases, it may be appropriate and economically feasible for the reviewer to perform a complete, independent calculation using a different, but appropriate method.

It is up to the reviewer to determine the appropriate method of review.

4.4 If the reviewer recommends revisions, the reviewer and originator will confer until any disagreements are resolved.

4.5 After determining that the calculation is acceptable, the reviewer will sign and date the cover page and initial and date the remaining pages.

4.6 A photocopy of the approved calculation record is made and filed in the central project file.

ENSR STANDARD OPERATING PROCEDURE

Number: 7130 Date of Issue: March 12, 1984

Title: Ground-Water Sample Collection from Monitoring Wells

Organizational Acceptance	Authorization	Date
Originator	Christopher Carlo	3-13-84
Department Manager	[illegible]	3/13/84
Divisional Manager	[illegible]	3-13-84
Group Quality Assurance Officer	[illegible]	3-13-84
Other		

Revisions	Changes	Authorization	Date
1	• Sect. 3.0 - Equipment checklists have been added.	JMW	9-5-86
	• Sect. 4.4 - The use of electronic sounding devices has been removed from procedures for obtaining water-level measurements.	CEM	9-11-86
	• Sect. 4.5 - Some unneccessary steps have been deleted from procedures for decontamination.		
	• Sect. 5.0 - The volume of ground water for purging wells has been changed from 4 to 10 volumes to 3 to 10 volumes.		
	• Sect. 6.2 - A more detailed description of bailing was added.		
	• Additional figures have been added.	Em	9-10-86
	• Miscellaneous rewording and renumbering for clarification.		

Title: Ground-Water Sample Collection from Monitoring Wells

1.0 Applicability

This Standard Operating Procedure (SOP) is concerned with the collection of valid and representative samples from ground-water monitoring wells. The scope of this document is limited to field operations and protocols applicable during ground-water sample collection.

2.0 Responsibilities

The site coordinator or his delegate will have the responsibility to oversee and ensure that all ground-water sampling is performed in accordance with the project-specific sampling program and this SOP. In addition, the site coordinator must ensure that all field workers are fully apprised of this SOP. The field team is responsible for proper sample handling as specified in SOP 7510, Handling and Storage of Samples.

3.0 Supporting Materials

The list below identifies the types of equipment which may be used for a range of ground water-sampling applications. From this list, a project-specific equipment list will be selected based upon project objectives, the depth to ground-water, purge volumes, analytical parameters and well construction. The types of sampling equipment are as follows:

- Purging/Sample Collection

  Bailers
  Centrifugal Pump
  Submersible Pump
  Peristaltic Pump

- Sample Preparation/Field Measurement

  pH Meter
  Specific Conductance Meter
  Filtration Apparatus
  Water-Level Measurement Equipment

Additional equipment to support sample collection and provide baseline worker safety will be required to some extent for each sampling task. The additional materials are separated into two primary groups: general equipment which is reusable for several samplings, and materials which are expendable.

- General

  Project-specific sampling program
  Deionized-water dispenser bottle
  Methanol-dispenser bottle
  Site-specific Health & Safety equipment (gloves, respirators, goggles)
  Field data sheets and/or log book
  Preservation solutions
  Sample containers
  Buckets and intermediate containers
  Coolers
  First-Aid kit

- Expendable Materials

  Bailer Cord
  Respirator Cartridges
  Gloves
  Water Filters
  Chemical-free paper towels
  Plastic sheets

Equipment checklists have been developed to aid in field trip organization and should be used in preparation for each trip.

4.0 Water-Level Measurement

4.1 Introduction

Prior to obtaining a water-level measurement, cut a slit in one side of the plastic sheet and slip it over and around the well, creating a clean surface onto which the sampling equipment can be positioned. This clean working area should be a minimum of eight feet square. Care will be taken not to kick, transfer, drop, or in any way let soil or other materials fall onto this sheet unless it comes from inside the well. Do not place meters, tools, equipment, etc. on the sheet unless they have been cleaned first with a clean rag.

After unlocking and/or opening a monitoring well, the first task will be to obtain a water-level measurement. Water-level measurements will be made using an electronic or mechanical device. Electronic measurement devices will be used in all wells wherein a clearly audible sound cannot be produced with a mechanical device.

4.2 Well Security

Unlock and/or open the monitoring well. Enter a description of condition of the security system and protective casing on the Ground-Water Sample Collection Record shown in Figure 1.

4.3 Measuring Point

Check for the measuring point for the well. The measuring point location should be clearly marked on the outermost casing or identified in previous sample collection records. If no measuring point can be determined, a measuring point should be established. Typically the top (highest point) of the protective or outermost well casing will be used as the measuring point. The measuring point location should be described on the Ground-Water Sample Collection Record and should be the same point used for all subsequent sampling efforts.

4.4. Measurement

To obtain a water-level measurement lower a clean steel, fiberglass tape into the monitoring well. Care must be taken to assure that the water-level measurement device hangs freely in the monitoring well and is not adhering to the wall of the well casing. The water-level measuring tape will be lowered into the well until the audible sound of the unit is detected or the light on an electronic sounder illuminates. At this time the precise measurement should be determined (to hundredth of a foot) by repeatedly raising and lowering the tape to converge on the exact measurement. The water-level measurement should be entered on the Ground-Water Sample Collection Record. As well point of measurement should be indicated; i.e., top of protective casing, top of pueriser, ground level.

4.5 Decontamination

The measurement device shall be decontaminated immediately after use with a methanol soaked towel. Generally only that portion of the tape which enters the water table should be cleaned. It is important that the measuring tape is never placed directly on the ground surface.

5.0 Purge-Volume Computation

All monitoring wells to be purged prior to sample collection. Depending upon the ease of purging, 3 to 10 volumes of ground water to be determined by hydrogeologing prior to sampling present in a well shall be withdrawn prior to sample collection or one volume if well can be purged dry. The volume of water present in each well shall be computed based on the length of water column and well casing diameter. The water volume shall be computed using Figure 2.

6.0 Well-Purging Methods

6.1 Introduction

Purging must be performed for all ground-water monitoring wells prior to sample collection in order to remove stagnant water from within the well casing and ensure that a representative sample is obtained. The following sections explain the proper procedures for purging and collecting water samples from monitoring wells.

Three general types of equipment are used for well purging: bailers, surface pumps, or down-well submersible pumps.

In all cases pH and/or specific conductance will be monitored during purging. Field parameter values will be entered on the Ground-Water Sample Collection Record along with the corresponding purge volume.

6.2 Bailing

In many cases bailing is the most convenient method for well purging. Bailers are constructed using a variety of materials; generally, PVC stainless steel, and Teflon®. Care must be taken to select a specific type of bailer that suits a study's particular needs. Teflon® bailers are generally most "inert" and are used most frequently. Keep in mind the diameter of each monitoring well so that the correct size bailers are taken to the site. It is preferable to use one bailer per well; however, field decontamination is a relatively simple task if required.

Bailing presents two potential problems with well purging. First, increased suspended solids may be present in samples as a result of the turbulence caused by raising and lowering the bailer through the water column. High solids concentrations may require that total suspended solids (TDS) and the chemical character of solids be evaluated during sample analyses. Second, bailing may not be feasible for wells which require that greater than twenty (20) gallons be removed during purging. Such bailing conditions mandate that long periods be spent during purging and sample collection or that centrifugal pumps be used. All ground-water collected from monitoring wells for subsequent volatile organic compound analyses shall be collected using bailers, regardless of the purge method.

6.3 Surface Pumping

Ground-water withdrawal using pumps located at the ground surface is commonly performed with centrifugal or peristaltic pumps.

All applications of surface pumping will be governed by the depth to the ground-water surface. Peristaltic and centrifugal pumps are limited to conditions where ground water need only be raised through approximately 20 feet of vertical distance. The lift potential of a surface pumping system will depend upon the net positive suction head of the pump and the friction losses associated with the particular suction line, as well as the relative percentage of suspended particulates.

Surface pumping can be used for many applications of well purging and ground-water sample collection. In all cases, pumping cannot be used for the collection of samples to be analyzed for volatile organic compounds (VOCs).

6.3.1 Peristaltic Pump

Peristaltic pumps provide a low rate of flow typically in the range of 0.02-0.2 gallons/min (75-750 ml/min). For this reason, peristaltic pumps are not particularly effective for well purging. Peristaltic pumps are suitable for purging situations where disturbance of the water column must be kept minimal for particularly sensitive analyses. Peristaltic pumps are most often used in conjunction with field filtering of samples and therefore can be used to obtain water samples for direct filtration at the wellhead.

6.3.2 Centrifugal Pump

Centrifugal pumps are designed to provide a high rate of pumping, in the range of 10-40 gallons per minute (gpm), depending on pump capacity. Discharge rates can also be regulated somewhat provided the pump has an adjustable throttle.

When centrifugal pumps are used, samples should be obtained from the suction (influent) line during pumping by an entrapment scheme as shown in Figure 3. Construction of this sampling scheme is relatively simple and will not be explained as part of this SOP. It is suggested that if samples cannot be obtained before going through the pump, that samples be obtained by using a bailer once pumping has ceased. Collecting samples from the pump discharge is not recommended.

6.3.3 Submersible Pump

Submersible pumps provide an effective means for well purging and in some cases sample collection. Submersible pumps are particularly useful for situations where the depth to water table is greater than twenty (20-30) feet and the depth or diameter of the well requires that a large purge volume be removed during purging.

ERT uses the Johnson-Keck pump model SP-81 which has a 1.75 inch diameter pump unit. The pump diameter restricts use to monitoring wells which have inside diameters equal to or greater than two (2) inches. As with other pump-type purge/sample collection methods, submersible pumps will not be used for the collection of samples for analyses of volatile organic compounds. Submersible pumps should never be used for well development as this <u>will</u> seriously damage the pump.

7.0 Sample Collection Procedures

7.1 Bailing

Obtain a clean/decontaminated bailer and a spool of polypropylene rope or equivalent bailer cord. Using the rope at the end of the spool tie a bowline knot or equivalent through the bailer loop. Test the knot for security and the bailer itself to ensure that all parts are intact prior to inserting the bailer into the well.

Remove the protective foil wrapping from the bailer, and lower the bailer to the bottom of the monitoring well and cut the cord at a proper length. Boiler rope should never touch the ground surface at any time during the purge routine.

Raise the bailer by grasping a section of cord using each hand alternately in a "rocking" action. This method requires that the samplers' hands be kept approximately 2-3 feet apart and that the bailer rope is alternately looped onto or off each hand as the bailer is raised and lowered.

Bailed ground water is poured from the bailer into a graduated bucket to measure the purged water volume.

For slowly recharging wells, the bailer is generally lowered to the bottom of the monitoring well and withdrawn slowly through the entire water column. Rapidly recharging wells should be purged by varying the level of bailer insertion to ensure that all stagnant water is removed. The water column should be allowed to recover to 70-90% of its static volume prior to collecting a sample. Water samples should be obtained from midpoint or lower within the water column.

Samples collected by bailing will be poured directly into sample containers from bailers which are full of fresh ground water. During sample collection, bailers will not be allowed to contact the sample containers.

7.2 Peristaltic Pump

Place a new suction and discharge line to the peristaltic pump. Silicon tubing must be used through the pump head. A second type of tubing may be attached to the silicon tubing to create the suction and discharge lines. Such connection is advantageous for the purpose of reducing tubing costs, but can only be done if airtight connections can be made. Tygon tubing will not be used when performing well purging or collecting samples for organic analysis. The suction line must be long enough to extend to the static ground-water surface and reach further should drawdown occur during pumping.

Measure the length of the suction line and lower it down the monitoring well until the end is in the upper 2-5 inches of the water column present in the well. Start the pump and direct the discharge into a graduated bucket.

Measure the pumping rate in gallons per minute by recording the time required to fill a selected volume of a bucket. Flow measurement shall be performed three times to obtain an average rate.

The pumping shall be monitored to assure continuous discharge. If drawdown causes the discharge to stop, the suction line will be lowered very slowly further down into the well until pumping restarts.

Measurements of pH and specific conductance will be made periodically during well purging. All readings will be entered on the Ground-Water Sample Collection Record.

Samples will be collected after the required purge volume has been withdrawn and the field parameters (pH and Specific Conductance) have stabilized.

When the sample bottles are prepared, each shall be filled directly from the discharge line of the peristaltic pump. Care will be taken to keep the pump discharge line from contacting the sample bottles. Ground-water samples requiring filtration prior to placement in sample containers, will be placed in intermediate containers for subsequent filtration or filtered directly using the peristatic pump.

At each monitoring point when use of the peristaltic pump is complete, all tubing including the suction line, pump head and discharge line must be disposed of. In some cases where sampling will be performed frequently at the same point, the peristaltic pump tubing may be retained between each use in a clean zip-lock plastic bag.

7.3 Centrifugal Pump

7.3.1 Direct Connection Method (Note: This method requires that the well casing be threaded at the top.)

Establish direct connection to the top of the monitoring well if possible using pipe connections, extensions, and elbows, with Teflon® tape wrapping on all threaded connections. If the centrifugal pump will subsequently be used for sample collection, a sample isolation chamber will be placed in the suction line configuration as shown in Figure 3.

Prime the pump by adding tap water to the pump housing until the housing begins to overflow.

Start the pump and direct the discharge into a graduated bucket or a bucket of known capacity (>2.5 gallons).

Start the pump and measure the pumping rate in gallons per minute by recording the time required to fill the graduated bucket. Flow measurement should be checked periodically to determine if pumping rates are continuous, fluctuating, or diminishing. If discharge stops, the pump will be throttled back to determine if pumping will restart at a lower rate. If pumping does not restart, the pump should be shut off to allow the well to recharge.

Measurements of pH and specific conductance will be made periodically during well purging. All readings will be entered on the Ground-Water Sample Collection Record. Samples will be collected after the required purge volume has been withdrawn and the field parameters (pH and Specific Conductance) have stabilized. Samples should be collected from an in-line discharge valve or with a bailer. The pump should be properly decontaminated between wells.

7.3.2 Down-Well Suction-Line Method

Lower a new suction line into the well. The suction line will have a total length great enough to extend to the water table and account for a minimum of five (5) feet of drawdown. Note should be made that drawdown may exceed the depth where pumping will terminate as a result of a limitation derived from suction-line conditions and the lift potential of the pump. All connections should be made using Teflon® ferrules and Teflon® thread wrapping tape. Run the pump as per Section 7.3.1.

At each monitoring well when use of a centrifugal pump is complete, all suction line tubing should be disposed of properly.

7.4 Submersible Pump

Prior to using a submersible pump, a check will be made of well diameter and alignment. A 1.75 inch diameter decontaminated cylindrical tube should be lowered to the bottom of each monitoring well to determine if the alignment or plumbness of a well is adequate to accommodate the submersible pump. All observations will be entered in the Ground-Water Sample Collection Record.

Slowly lower the submersible pump into the monitoring well taking notice of any roughness or restrictions within the riser.

Count the graduations on the pump discharge line and stop lowering when the stainless steel portion is below the uppermost section of the static water column within monitoring well. Secure the discharge line and power cord to the well casing.

Connect the power cord to the power source (i.e., rechargeable battery pack or auto battery monitor) and turn the pump on (forward mode). When running, the pump can usually be heard by listening near the well head.

Voltage and amperage meter readings on the pump discharge must be checked continuously. The voltage reading will decline slowly during the course of a field day representing the use of power from the battery. Amperage readings will vary depending upon the depth to water table. Amperage readings greater than 10 amps usually indicate a high solids content in the ground water which may cause pump clogging and serious damage. If a steady increase in amperage is observed, the pump should be shut off, allowed to stop, switched to the reverse mode, stopped again and then placed in forward mode. If high amperage readings persist, the pump should be withdrawn and checked using the large upright cylinder and tap water. Ground-water conditions such as high solids may require that an alternate purge/sample method be used.

Drawdown must also be monitored continuously by remaining near the well at all times and listening to the pump. When drawdown occurs, a metallic rotary sound will be heard as the pump intake becomes exposed and ceases to discharge water, but continues to run. The pump should be lowered immediately to continue pumping water within the uppermost section of the static water column. NOTE: The submersible pump cannot be allowed to run while not pumping for more than five seconds or the pump motor will burn out.

If drawdown continues to the extent that the well is pumped dry, the pump should be shut off and the well allowed to recharge. This on/off cycle may need to be repeated several times in order to purge the well properly.

Measurements of the pumping rate, pH, and specific conductance should be made periodically during well purging. All readings and respective purge volumes should be entered on the Ground-Water Sample Collection Record.

While pumping is on-going and when sample bottles are prepared, bottles will be filled directly from the discharge line of the pump taking care not to touch sample bottles to the discharge line.

At each monitoring well when use of the submersible pump is complete, the pump, discharge line and power cord shall be decontaminated according to the procedures contained in the SOP for Decontamination.

8.0 Sample Preparation

8.1 Introduction

Prior to sample transport or shipment, ground-water samples may require filtration and/or preservation dependent on the specific type of analysis required.

Specific preservation techniques are described in the EPA document, Handbook for Sampling and Sample Preservation of Water and Wastewater (EPA-600/4-82-029). The EPA manual and laboratory manager should be consulted during the planning stage of the project. Project-specific sampling plans shall be assembled using the approved procedures obtained from the EPA manual.

8.2 Filtration

Ground-water samples collected for dissolved metals analyses will be filtered prior to being placed in sample containers. Ground-water filtration will be performed using a peristaltic pump and a 0.45 micron, water filter. Typically the water filters are 142 mm in diameter and are usually placed in 142 mm polycarbonate housings.

The filtration of ground-water samples shall be performed either directly from the monitoring well or from intermediate sample containers such as decontaminated buckets. In either case, well purging shall be performed first. Fresh ground water shall then be filtered and discharged from the filtration apparatus directly into sample containers. For most dissolved metal analyses, pH adjustment of the sample is also required and shall be performed after filling the sample bottles. This is generally accomplished using laboratory supplied compounds such as sulfuric or nitric acid and sodium hydroxide.

9.0 Documentation

A number of different documents must be completed and maintained as a part of ground-water sampling effort. The documents provide a summary of the sample-collection procedures and conditions, shipment method, the analyses requested and the custody history. The list of documents is:

- Ground-water sample collection record
- Sample labels
- Chain of custody forms and tape
- Shipping receipts

Sample labels shall be completed at the time each sample is collected and will include the information listed below. A sample label is shown in Figure 4.

- Client or project name
- Sample number
- Designation (i.e., identification of sample point no.)
- Analysis
- Preservative (e.g., filtration, acidified pH<2 HNO_3)
- Sample-collection date
- Sampler's name

Figure 5 displays the chain of custody record used by ERT. The chain of custody form is the record sample collection and transfer of custody. Information such as the sample collection date and time of collection, sample identification and origination, client or project name shall be entered on each chain of custody record. In accordance with 40 CFR 261.4(d) the following information must accompany all ground water samples which are known to be non-hazardous and to which U.S. Department of Transportation and U.S. Post Office regulations do not apply. Such information is:

- sample collector's name, mailing address and telephone number,
- analytical laboratory's name, mailing address and telephone number,
- quantity of each sample,
- date of shipment, and
- description of sample.

The chain of custody forms provide a location for entry of the above-listed information.

10.0 References

EPA, Handbook for Sampling and Sample Preservation of Water and Wastewater EPA-600/4-82-029, September 1982.

Geotrans, Inc. RCRA Permit Writer's Manual, Ground-Water Protection prepared for U.S. EPA. Contract No. 68-01-6464, October 1983.

Code of Federal Regulations, Chapter 40 Section 261.4(d).

Figure 1

ENSR

Well No. ______

GROUND WATER SAMPLE COLLECTION RECORD

Job No. __________ Date: __________

Location: ______________________________ Time: S _____

Weather Conds.: ______________________________ F _____

1. WATER LEVEL DATA: (from ToC) ToC Elevation (from LS) __________
   a. Total Well Length (+ TC) __________ (known, meas.) Tape Corr. (TC) __________
   b. Water Table Elev. (+ TC) __________ Well Dia. __________
   c. Length of Water Column __________ (a-b)

2. WELL PURGING DATA:
   a. Purge Method ______________________________
   b. Required Purge Volume (@ _____ well volumes) ______________________________
   c. Field Testing: Equipment Used ______________________________

Volume Removed	T°	PH	Spec. Cond.	Color

3. Sample Collection: Method ______________________________

Container Type	Preservation	Analysis Req.

Comments: ______________________________

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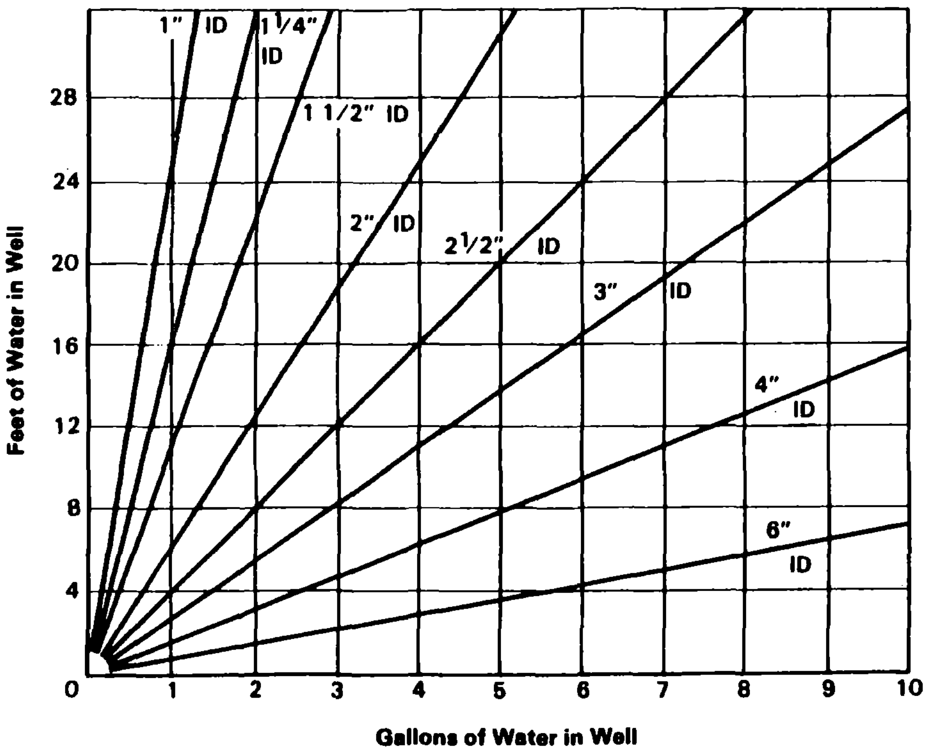

(a) Graphical Explanation

Volume/Linear Ft. of Pipe		
ID(in)	Gal	Liter
1/4	0.003	0.010
3/8	0.006	0.022
1/2	0.010	0.039
3/4	0.023	0.087
1	0.041	0.154
2	0.163	0.618
3	0.367	1.39
4	0.653	2.47
6	1.47	5.56

(b) Volume Factors

Figure 2 Purge Volume Computation

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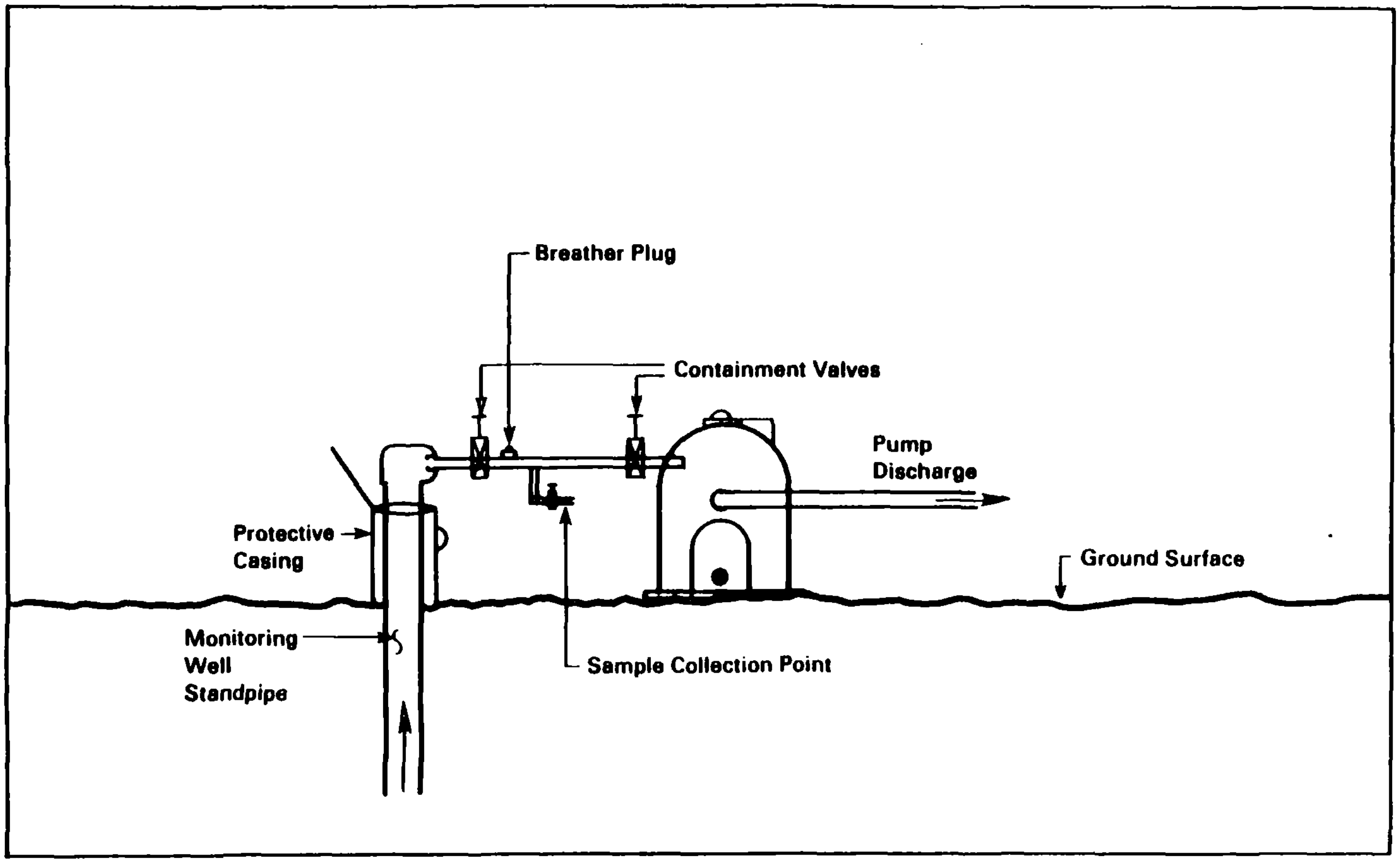

Figure 3 Down Well Suction Line Configuration

CLIENT ____________________

SAMPLE NO. ____________________

DESIGNATION ____________________

ANALYSIS ____________________

PRESERVATIVE ____________________

DATE __________ BY __________

Figure 4 Sample Container Label

0895J

CHAIN OF CUSTODY RECORD

Client/Project Name	Project Location	ANALYSES
Project No.	Field Logbook No.	
Sampler: (*Signature*)	Chain of Custody Tape No.	

Sample No./ Identification	Date	Time	Lab Sample Number	Type of Sample							REMARKS

Relinquished by: (*Signature*)	Date	Time	Received by: (*Signature*)	Date	Time
Relinquished by: (*Signature*)	Date	Time	Received by: (*Signature*)	Date	Time
Relinquished by: (*Signature*)	Date	Time	Received for Laboratory: (*Signature*)	Date	Time
Sample Disposal Method:			Disposed of by: (*Signature*)	Date	Time

SAMPLE COLLECTOR	ANALYTICAL LABORATORY	No

1974-3-84

Figure 5 Sample Chain-of-Custody Record

ENSR STANDARD OPERATING PROCEDURE

Number: 7210 Date of Issue: 1st Quarter, 1984

Title: Rock Coring

Organizational Acceptance	Authorization	Date
Originator	Charles S Martin	3/2/84
Department Manager	Arthur S [illegible]	3/2/84
Divisional Manager	Elaine Moore	3-2-84
Group Quality Assurance Officer	[illegible]	3/2/84
Other		

Revisions	Changes	Authorization	Date
1	Update	SMW	3/2/84
		CEM	3/2/84
		AGL	3/2/84
		EM	3-2-84

STANDARD OPERATING PROCEDURE

Title: Rock-Core Drilling

Date: 1st Qtr 19
Number: 7210
Revision: 1

1.0 Purpose and Applicability

This SOP describes the methods used for obtaining rock core samples for establishing the stratigraphy, structure, and geotechnical properties of the rock.

2.0 Responsibilities

It is the responsibility of the contract driller to provide the necessary equipment for coring and to collect the designated samples.

It is the responsibility of the project geologist/engineer to observe the coring operation and to log all cores that are collected using the approved forms.

3.0 Supporting Materials

All drill rigs used for rock coring shall be equipped with hydraulic feed. Driven or drilled-in flush joint casing shall be employed. For driven casing, it may not be necessary to record the casing blows. Drill rods for drilling rock should be NW in size to minimize vibration and chattering. Rock core size shall be NX or NQ (Wire Line) or as required by the Project Task Plan. Core barrels shall be of the improved double-tube varieties such as the Christensen Series C or D models or equivalent, and shall be equipped with a split inner tube. In general, 5-foot barrels will be employed at the discretion of the inspecting geologist.

Core boxes shall be provided by the contract driller for storage purposes.

4.0 Coring Procedures

4.1 General Information

4.1.1 Typically, soil sampling and rock coring will be performed in the same borehole. Casing shall be required for the full depth of the overburden in borings in which rock will be cored.

4.1.2 The inspecting geologist may allow the use of drilling mud to advance the boring for unusual combinations of soil and ground-water conditions. Prior to commencing rock drilling, however, casing shall be inserted in the mudded hole and firmly seated in rock. Biodegradable drilling fluids such as Johnson's Revert shall be used. Other fluids, such as bentonite slurry, is subject to the approval of the project geologist or his delegate.

4.2 Procedure

4.2.1 Casing shall be firmly seated into the bedrock surface prior to commencing rock drilling. The drilling methods employed shall be adjusted continuously to obtain maximum core recovery of the rock being drilled. This will involve careful attention to the rates of feed and rotation and the rate of flow of drilling fluid. These rates shall be adjusted as necessary to maximize recovery. Types of bits shall also be carefully selected as to diamond size, matrix and the configuration of the bit face and water ports, so as to produce the maximum recovery for each type of rock. The inspecting geologist may require that the type of bits be varied in each hole as different rock types are encountered. In no case shall worn or damaged bits be used. Core lifters shall be checked and replaced as soon as excessive wear is evident.

4.2.2 The inspecting geologist shall make an independent determination of depth measurements and check his determinations with those made by the drilling foreman. Any discrepancy shall be resolved in the field as soon as it is discovered. All depth measurements shall be made in feet and tenths of feet.

4.2.3 Every effort should be made to use clear water as a drilling fluid. In the event that this is impractical, recirculated water may be used at the discretion of the inspecting geologist, providing a settling tank and filtering system is provided. If drilling mud is used to advance the boring through the overburden, the hole shall be washed free of all mud prior to the commencement of rock drilling.

4.2.4 To minimize core losses in soft, erodable rock, the following measures shall be required by the inspecting geologist:

- Drilling shall be restricted to short runs of 2 to 3 feet;
- Drilling water pressure shall be kept low (under 150 psi);
- Feed pressure shall be kept under 100 psi.

4.2.5 Split-spoon drive samples may be taken in any zones where it is not possible to drill and obtain satisfactory recovery of soft erodable rocks. Satisfactory recovery for this purpose is defined as 50% or greater.

4.2.6 The inspecting geologist shall not permit a full coring run to be drilled if he suspects core was left in the hole on the previous run. If this is believed to have occurred, he shall direct that the next coring run be shortened by the length of core believed to have been left in the hole. This is necessary to prevent blocking the core barrel and grinding of the core.

4.3 Sample Handling and Storage

4.3.1 Upon removal of the core barrel from the drill hole, the split inner tube shall be removed and opened and, if necessary to facilitate accurate logging, the core shall be washed while it rests in the liner half. Care shall be used in washing to avoid removing small pieces of core or soft joint or vein fillings. If the rock is soft, friable, or otherwise erodable and, in the opinion of the inspecting geologist, washing will damage the core, the washing process shall be omitted.

4.3.2 The core shall be placed in wooden boxes specially constructed to hold and store rock cores. The core shall be placed in the core box with the top of the run at the upper left corner and the remaining core placed sequentially from left to right and from the rear (nearest the cover hinge) of the box to the front.

4.3.3 Wooden blocks marked with the appropriate depth and run number shall be placed between each separate core run. In addition, wherever core is lost due to the presence of a cavity or large joint (open or filled), a spacer shall be placed in the proper relative position in the core box. The spacer shall be the same length as that of the lost core and the depth range shall be marked on the spacer along with the reason for the missing core (e.g., cavity, large joint, etc.)

4.3.4 The core box shall be marked on the top and two ends with the client's name, site identification, boring number, depth range, and box number. The RQD shall be indicated on all core boxes.

5.0 Documentation

5.1 The inspecting geologist shall prepare a field boring log of each boring. The boring log shall be kept current. In addition to the data entries noted, the inspecting geologist should be careful to observe and note any of the following:

- Information on any blocking or grinding of the core during the run;

- Changes in color or flow rate of the return water;

- Any unusual action of the drill rods, sudden chattering of the core barrel, rapid drop of the drill rods, etc.

Other information to include on the boring log shall be:

- Elevation of bottom of casing when seated on bedrock.
- Type of core drill, including size of core.
- Length of core recovered for each length drilled, with resulting percentage of recovery.
- Elevation at which rock was encountered.
- Elevation of each change in type of bedrock.
- Elevation of any depth of drilling at which drill water is lost in making borings.
- Time required to drill each foot.

5.2 The bedrock shall be described in accordance with the procedures outlined in the SOP 7211 (Logging of Rock Cores) and will include:

1. Type: Granite, slate, shale, limestone, gneiss, sandstone, etc.
2. Condition: Broken, fissured, laminated, jointed, massive, etc.
3. Hardness: Soft, hard, medium hard, very hard, etc.

5.3 The inspecting geologist shall identify the borehole by marking the identification number of the borehole on the casing.

5.4 All documentation shall remain in the project files for an indefinite period of time following completion of the project.

ROCK CORE SAMPLE LOG

PROJECT NO. ______________________ PROJECT NAME ______________________

DATE ______________________

SITE LOCATION/BORING NO. ______________________

MONITORING WELL INSTALLED (Y, N) ________ BORING LOG (Y, N) ____________

TOTAL DEPTH ____________

LENGTH OF CORE ____________

RECOVERY % ____________

CORE BOX NO. ____________

EQUIPMENT USED ______________________

COLLECTOR'S NAME ______________________

TOTAL TIME __________ - __________ HRS.

ROCK DESCRIPTION: TYPE/NAME ______________________

COLOR ______________________

DENSITY/HARDNESS ______________________

STRUCTURAL/TEXTURAL FEATURES ______________________

____

____

COMMENTS ______________________

____

LAB DESIGNATION ______________________

FURTHER ANALYSIS (TYPE) ______________________

Project ______________ Site ______________ **BORING** __________ Sh 1 of ____

Date Started ______________ Completed ______________ Ground Elevation ______________

Total Depth ______________ Location ______________ Logged by ______________

Casing I.D. ______________ Contractor ______________

Remarks ______________

Elev. Feet	Depth Feet	Sample				Graphic Log	Sample Description	Equipment Installed
		Type & Number	Blows per 6 In.	Depth Range	Rec.			

ENSR

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ENSR STANDARD OPERATING PROCEDURE

Number: 7211 Date of Issue: 1st Quarter, 1984

Title: Logging of Rock Cores

Organizational Acceptance	Authorization	Date
Originator	Charles S Martin	3/2/84
Department Manager	Arthur S Lazarus	3/2/84
Divisional Manager	Elaine Moore	3-2-84
Group Quality Assurance Officer	[illegible]	3/2/84
Other		

Revisions	Changes	Authorization	Date
1	Update	SMW	3/2/84
		CEM	3/2/84
		ASL	3/2/84
		EM	3-2-84

STANDARD OPERATING PROCEDURE

Title: Logging of Rock Cores

Date: 1st Qtr 1984
Number: 7211
Revision: 1

1.0 Purpose and Applicability

This SOP describes the procedures for the logging of rock core in order to provide a written description of the rock conditions encountered in individual test borings. The basic objective of describing rock cores is to provide a concise record of important geological and physical characteristics of the rock core such as: rock type/name, lithological/structural features, any physical conditions, including alteration, and any special geological, mineralogical, or other features pertinent to interpretation of the subsurface conditions.

2.0 Responsibilities

It shall be the responsibility of the project geologist/engineer to maintain accurate records of all core samples that are collected and also any coring attempts which fail to retrieve a sample.

3.0 Supporting Materials

- Boring logs
- Hand lens for close inspection
- Marker for labelling
- Core boxes (usually provided by drilling subcontractor)
- Dilute hydrochloric acid
- Rock hammer and pen knife
- Six-foot folding rule

4.0 Logging Procedures

4.1 General Information

The following features shall be noted for all rock types:

- color, grain size, grain shape, and the mineralogy of the grains;
- attitude of bedding, cleavage or foliation planes, and the ease of splitting along such planes;
- the attitude and degree of jointing, whether open or filled, as well as evidence of shearing, crushing, or faulting;

- the degree of alteration or weathering, hardness of the rock, and other engineering properties;

- the "RQD" (Rock Quality Designation) for NX or larger size cores.

4.2 Igneous and Metamorphic Rocks

4.2.1 A typical description of an igneous or metamorphic rock shall include:

- name or generalized group name;

- color;

- identification of the major minerals and an estimation of the amount of each mineral (percentage estimates may be used);

- textural information and textural variations including mineral orientations, grain shapes, intergrowths, description of phenocrysts, and grain-size information;

- larger structural features such as jointing, flow banding, dip of beds, contact relationships, nature of metamorphism, and any hydrothermal effects;

- any weathering or mechanical characteristics.

4.2.2 In the field, igneous rocks should be classified according to texture and mineralogy/color to arrive at a generalized group name (for example, granite, anorthosite or basalt). Field descriptions of cataclastic rocks shall include information on the nature of the cataclasis, the type of original rock, size of blocks or clasts, presence of gouge, mineralization, and the width of zone(s).

4.2.3 If a detailed petrographic examination is performed, a more detailed classification system shall be utilized.

- Igneous rocks shall be classified according to nomenclature recommended by the IUGS Subcommission on the Systematics of Igneous Rocks (1973).

- Metamorphic rocks, with the exception of cataclastic rocks, shall be classified according to the manner outlined in Travis (1955). A mineral name should prefix a structural term (e.g., garnet-mica schist or muscovite-biotite-quartz gneiss; the prefix "meta" may be used for rocks that retain their original fabric e.g., metagabbro).

- Cataclastic rocks should be classified according to Higgins (1971).

4.3 Sedimentary Rocks

4.3.1 A typical description of a sedimentary rock shall include:

- name;
- color;
- texture of the rock, including any information on grain size(s) and identification and estimates of amounts of minerals and fossils;
- information on lithification and diagenesis, sedimentary structures, and stratigraphic relationships;
- the nature of the cementing material occupying the intergranular spaces;
- any sedimentary structures including a description of the bedding, and any features which are useful in determining geopetal relationships;
- a description of the weathering and engineering properties.

4.3.2 Classification of sedimentary rocks, both in core and in the field, should be based upon grain size (Wentworth, 1922), color or mineralogy and hardness;

4.3.3 If detailed petrographic examination is performed, one of the more deailed classification systems should be used. The system by Folk (1974) is suggested.

5.0 Special Tests/Analyses

5.1 Numerous analytical techniques are available to assist the core logger in his examination of the rock core. These include:

- thin section analysis;
- chemical analysis;
- radiometric age determinations;
- other special tests.

5.2 Samples to be tested or analyzed shall be selected and transmitted in accordance with required procedures.

6.0 Documentation

6.1 All descriptive data shall be noted on the final/geologic boring by the supervising geologist(s) for core logging.

6.2 All final boring logs shall be reviewed by the site or regional geologist to assure completeness and technical accuracy.

6.2.1 Any changes, additions, or deletions to the logs shall be made so that the original entry (words and/or numbers) is still legible. Under no circumstances will any erasures be allowed. If extensive deletions and additions are necessary, then a second boring log form may be attached to the original and labelled with the original sheet number and a small "a" after said number.

6.2.2 Upon completion of this review, the site or regional geologist shall initial and date the "Checked by" section of the boring log.

6.3 All documentation shall remain in the project files for an indefinite period of time following completion of the project.

Project ____ Site ____ **BORING** ____ Sh 1 of ____

Date Started ____ Completed ____ Ground Elevation ____

Total Depth ____ Location ____ Logged by ____

Casing I.D. ____ Contractor ____

Remarks ____

Elev. Feet	Depth Feet	Sample				Graphic Log	Sample Description	Equipment Installed
		Type & Number	Blows per 6 In.	Depth Range	Rec.			

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ROCK CORE SAMPLE LOG

PROJECT NO. ______________________ PROJECT NAME ______________________

DATE ______________________

SITE LOCATION/BORING NO. ______________________

MONITORING WELL INSTALLED (Y, N) ________ BORING LOG (Y, N) ________

TOTAL DEPTH ______________

LENGTH OF CORE ______________

RECOVERY % ______________

CORE BOX NO. ______________

EQUIPMENT USED ______________________

COLLECTOR'S NAME ______________________

TOTAL TIME __________ - __________ HRS.

ROCK DESCRIPTION: TYPE/NAME ______________________

COLOR ______________________

DENSITY/HARDNESS ______________________

STRUCTURAL/TEXTURAL FEATURES ______________________

____

____

COMMENTS ______________________

____

LAB DESIGNATION ______________________

FURTHER ANALYSIS (TYPE) ______________________

0881J

ENSR **STANDARD OPERATING PROCEDURES**

Number: 7220

Date of Issue: 2nd Qtr. 1989

Title: Monitoring Well Construction and Installation

Organizational Acceptance	Authorization	Date
Originator	[signature]	3-23-89
Technical Reviewer	[signature]	4-10-89
Technical Reviewer	William M. Gregg	4-18-89
Technical Reviewer	[signature]	5-2-89
Quality Assurance		

Revisions No.	Changes	Authorization	Date
2	Complete Rewrite	[signature]	5-12-89

ENSR STANDARD OPERATING PROCEDURE

Number: 7220 Date of Issue: 1st Quarter, 1984

Title: Monitoring Well Construction

Organizational Acceptance	Authorization	Date
Originator	Charles S Martin	3/2/84
Department Manager	Arthur S. [illegible]	3/2/84
Divisional Manager	[illegible] Moore	3-2-84
Group Quality Assurance Officer	[illegible]	3/2/84
Other		

Revisions	Changes	Authorization	Date
1	Update	[illegible]	3/2/84
		CEM	3/2/84
		ASL	3/2/84
		Em	3-2-84

1283a (12/78)

Title: Monitoring Well Construction and Installation

1.0 Purpose and Applicability

This SOP establishes the method for installing ground water monitoring wells. These wells will be installed to monitor the depth to ground water, to measure aquifer properties, and to obtain samples of ground water for chemical analysis.

2.0 Definitions

Annulus: The space between the borehole wall and the outside of the well screen or riser pipe.

Filter Pack: A well-graded, clean sand or gravel placed around the well screen to prevent the entry of very fine soil particles.

Grout Plug: A cement/bentonite mixture use to seal a borehole that has been drilled to a depth greater than the final depth at which the monitoring well is to be installed.

Guard Pipe: A pipe, usually made of steel, placed around that portion of the well riser pipe that extends above the ground surface. As well as providing security to a well, it may provide a fixed elevation for surveying.

Riser Pipe: The section of unperforated well construction material used to connect the well screen with the ground surface. Frequently it is made of the same material and has the same diameter as the well screen.

Road Box: A man-hole set into the ground around a well installation. Usually constructed in areas where the monitoring well cannot extend above the ground surface for traffic or security reasons.

Tremie Pipe: A small diameter pipe that will fit in the annulus and is used to inject filter sands, seal materials, or cement/bentonite grout under pressure.

Well Screen: That portion of the well casing material that is perforated in some manner so as to provide a hydraulic connection to the aquifer. Typically a well screen has slots but holes, slits, louvers, and other perforations can, in some situations, be used.

3.0 Health and Safety Considerations

Monitoring well installation may involve chemical hazards associated with materials in the soil or aquifer being explored; and always involves physical hazards associated with the drill rig and well construction methods. When wells are to be installed in locations where the aquifer and/or overlying materials may contain chemical hazards, a Health and Safety Plan must be prepared and approved by the Health and Safety Officer before field work commences.

In addition, the following protective measures are required:

- all persons within 50 feet of the drill rig must wear hard hats and safety shoes. Hearing protection must be provided during periods of excessive noise; and

- personnel who are not directly involved in overseeing, inspecting or performing the drilling and well installation will remain at least 100 feet away from the drill rig.

4.0 Quality Assurance Planning Considerations

The following aspects of monitoring well design and installation procedures will depend on project-specific objectives and circumstances and should be addressed in the Quality Assurance Project Plan (QAPP).

- Construction materials for well screen, riser, filter pack and seals;

- Borehole drilling method;

- Depth and length of screen;

- Location and composition of seals; and

- Well head completion and protection.

Some states and EPA Regions have promulgated comprehensive guidelines for monitoring well configuration, and for subsurface investigation procedures. These will be followed as applicable, and the adaption of this SOP to accommodate those requirements will be explained in the QAPP.

5.0 Responsibilities

It is the responsibility of the Project Manager to ensure that each project involving monitoring well installation is properly planned and executed, and that the safety of personnel from chemical and physical hazards associated with drilling and well installation is protected.

Some states have specific requirements regarding the construction of monitoring wells. It is the responsibility of the Project Manager to understand these regulations and any permitting requirements that may be necessary, and to ensure that the well installation program complies with all state and local requirements.

It is the responsibility of the Project Geologist or Engineer to directly oversee the construction and installation of the monitoring well by the subcontract driller to ensure that the well-installation specifications defined in the project work plan are adhered to and that all pertinent data are recorded on the approved forms.

6.0 Training/Qualifications

Each person designing monitoring wells for ENSR projects and overseeing their installation should be a degreed geologist or hydrogeologist with at least two years experience in ground water monitoring. Specific training and/or orientation will be provided for each project to ensure that personnel understand the objectives and special circumstances and requirements of that project.

7.0 Supporting Materials

The monitoring well shall consist of a commercially available well screen constructed of PVC, stainless steel, teflon, or fiberglass pipe of minimum 2-inch nominal diameter. The length of the screen and the size of the screen slots shall be determined by the inspecting geologist or specified in the project work plan depending upon the grain-size distribution of the aquifer materials. PVC, stainless steel, steel, teflon, or fiberglass riser pipe of minimum 2-inch nominal diameter shall be used to complete the monitoring well to ground surface. The riser pipe shall be connected by flush-threaded, coupled or welded watertight joints. No solvent or anti-sieze compound shall be used on the joints.

The section of riser pipe that sticks up above ground shall be protected by a steel guard pipe set at least 2 feet into a concrete surface seal. The top of the guard pipe shall have a vented lockable cap. Alternatively, a road box may be installed, if it satisfies the security requirements of the project. Road-box installations must use a watertight seal inside of the riser pipe to prevent surface water from entering the well.

Other materials used for well construction include silica sand, bentonite, cement, and a calibrated tape for length measurements and water-level measurements. Construction materials are generally provided by the drilling subcontractor.

8.0 Method

8.1 Borehole Requirements

The diameter of the borehole must be a minimum of 2 inches greater than the outside diameter of the well screen or riser pipe used to construct the well. This is necessary so that sufficient annular space is available to install filter packs, bentonite seals, and grout seals.

Rotary drilling methods requiring bentonite-based drilling fluids should be used with caution to drill boreholes that will be used for monitoring well installation. The bentonite mud builds up on the borehole walls as a filter cake and permeates the adjacent formation, significantly reducing the permeability of the material adjacent to the well screen.

If water or other drilling fluids have been introduced into the boring during drilling or well installation, samples of these fluids should be obtained and analyzed for chemical constituents that may be of interest at the site.

8.2 Procedure for Construction

8.2.1 After drilling and soil sampling have been completed, the borehole shall be checked for total open depth with a weighted, calibrated tape measure.

8.2.2 If the borehole has been advanced to a depth greater than that of the bottom of the well to be installed, bottom grouting, or bentonite pellet sealing, of the borehole will be required. A heavy plumb bob on a calibrated tape shall be used to determine the total depth of the boring. This depth measurement shall be used with the required bottom elevation of the well screen to calculate the thickness of the grout plug. If bottom grouting is necessary, then provisions should be made to support the screen and riser pipe to prevent them from sinking into the grout. The depth to the top of the grout should be checked often with a weighted tape measure.

8.2.3 The assembled screen and riser or its constituent parts shall be decontaminated with a detergent and water wash and triple deionized water rinse. Steam-cleaning also can be done to decontaminate the well materials. Decontaminated well components should be wrapped in plastic until installed in the boring. All personnel handling the decontaminated well components should exercise great care not to contaminate these components as they are installed in the borehole.

8.2.4 The well screen and riser pipe generally are assembled as they are lowered into the borehole. As the assembled well is lowered, care shall be taken to ensure that it is centered in the hole. In boreholes which are determined to be not plumb, centralizers should be used on the tail pipe below the screen and/or the midpoint and top of the screen. This will assure that the screened portion of the well is centrally located in the borehole with a uniform thickness of sand or filter pack between the screen and the borehole wall. In holes greater than 25 feet in depth, centralizers should be used.

8.2.5 The annular space surrounding the screened section of the monitoring well and at least 1 foot above the top of the screen shall be filled with an appropriately graded, clean sand or gravel. In no case shall the sand pack be longer than 1.5 times the length of the screen. A minimum 1-foot thick layer of very fine sand (i.e., sand-blasting sand) should be placed immediately above the well screen sand pack. This layer is designed to prevent the infiltration of sealing components (bentonite or grout) into the sand pack. As each layer is placed, a weighted tape should be lowered in the annular space to verify the depth to the top of the layer.

Depending on the depth of the well, the diameters of the borehole and well materials, and the depth to the static water level, satisfactory placement of the sand pack may require the use of a tremie pipe.

8.2.6 Bentonite seals, either pellets or slurry, a minimum of 2 feet thick shall be installed immediately above the artificial gravel pack in all monitoring wells. The purpose of the seal is to provide a barrier to vertical flow of water in the annular space between the borehole and the well. Bentonite is used because it swells significantly upon contact with water. Pellets generally can be installed in shallow boreholes by pouring them very slowly from the surface. If they are poured too quickly, they may bridge at some shallow, undesired depth. Powdered bentonite shall be installed by mixing a very thick slurry and using . tremie pipe to inject the seal material at the desired depth in the borehole. Bentonite slurry should be pumped into the annular space using a side-discharge tremie pipe located about 2 feet above the fine-sand pack. Side discharge will ensure the integrity of the sand pack.

In situations where the monitoring well screen straddles the water table, the seal will be in the unsaturated zone and pure bentonites (pellets or powder) will not work effectively as seals due to dessication. Seals in this situation should be a cement/bentonite mixture containing 2 to 10 percent bentonite by weight. This type of mixture shall be tremied to the desired depth in the borehole.

8.2.7 The remaining length of borehole shall be backfilled with grout to within 2 feet of the ground surface. This grouting will consist of a cement/bentonite mixture. A tremie pipe shall be used to install the grout. Drill cuttings, even those known not to be contaminated, shall not be used as backfill material.

8.2.8 The steel guard-pipe shall be placed around the riser, and the borehole around the guard pipe shall be dug out to approximately a 1-foot radius to a depth of 2 feet, and filled with concrete. The concrete pad shall be sloped so that drainage occurs away from the well. All completed wells will have identification numbers clearly painted on the cap and guard pipe with bright colored paint.

Generally, the protective guard pipe will be lockable. A point on the top of the riser pipe will be marked (paint spot or cut notch) to indicate the surveyed elevation position, known as the "measuring point" (MP).

A vent hole must be installed in the protective casing in an area that is protected from precipitation. Road box installations should not be vented.

8.2.9 Measure the depth to the stabilized water level and record on the ground water monitoring well detail report (shown as Figure 1).

8.2.10 At some point after installation of a well and prior to use of the well for water level measurements or water quality samples, development of the well shall be undertaken in accordance with ENSR SOP 7221, Monitoring Well Development.

9.0 Quality Control Checks and Acceptance Criteria

- The borehole will be checked for total open depth, and extended by further drilling or shortened with a grout plug, if necessary, before any well construction materials are placed.
- Water level will be checked repeatedly during well installation to ensure that the positions of well screen, sand pack and seal, relative to water level, conform to project requirements.
- The depth to the top of each layer of packing (i.e., sand, bentonite, grout, etc.) will be verified and adjusted if necessary to conform to the requirements of this SOP and the QAPP before the next layer is placed.

10.0 Documentation

During installation of each monitoring well, a series of measurements shall be taken and recorded. These measurements shall include:

- length of tail pipe (if used)
- length of screen
- length of riser pipe
- total length of well
- depth to stabilized water level

Other data include the screen and riser pipe materials, diameters of the respective components, screen slot size, type and thickness of the sand pack, thicknesses and different types of grouting materials, and elevation of the top of the guard pipe, established measuring point, and ground surface after surveying is complete. If water or other drilling fluids have been introduced into the boring during drilling or well installation, samples of fluids should be obtained and analyzed for chemical constituents that may be of interest at the site.

All data shall be recorded on site onto the ground water monitoring well detail report (shown as Figure 1) and all wells shall be referenced onto the appropriate site map. A field book and/or boring log can be used as additional means of recording data. In no case shall the field book or boring log take the place of the ground water monitoring well detail report. All documentation shall remain in the project files indefinitely.

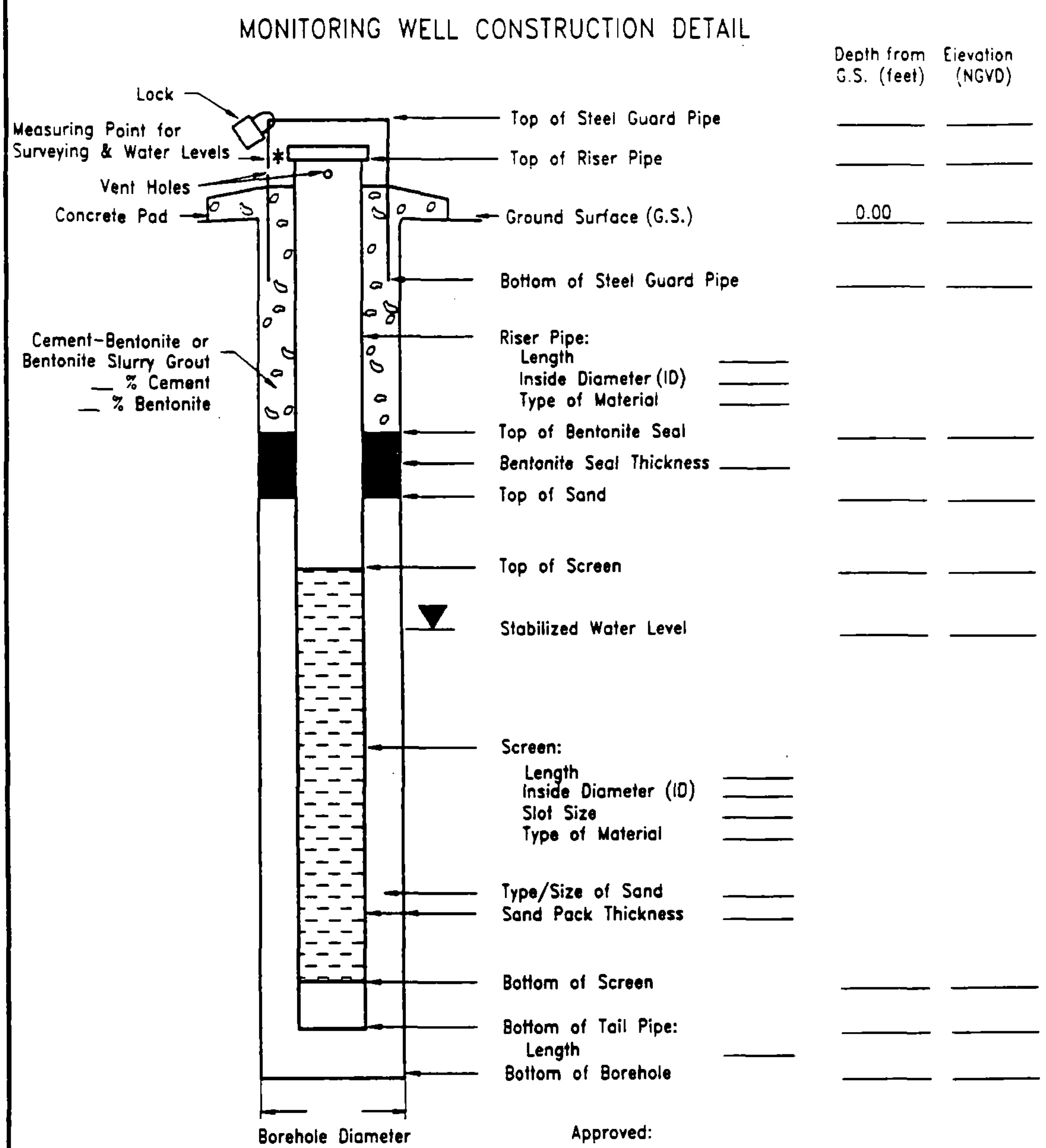
Figure 1

Project No: ____________ Client: ____________ Site: ____________ WELL No:

Well Location: ________________________________ Date installed: __/__/__

Contractor: ____________ Method: ____________ Inspector: ____________

MONITORING WELL CONSTRUCTION DETAIL



Approved:

* Describe Measuring Point:

____

________________ ________
Signature Date

ENSR.

ENSR

STANDARD OPERATING PROCEDURES

Number: 7221

Date of Issue: 2nd Qtr. 1989

Title: Monitoring Well Development

Organizational Acceptance	Authorization	Date
Originator	L. Cosgrave	3-23-89
Technical Reviewer	[illegible]	4-10-89
Technical Reviewer	William M. Gregg	4-18-89
Technical Reviewer	M. R. Vest	5-2-89
Quality Assurance	[illegible]	5-12-89

Revisions No.	Changes	Authorization	Date
0			

Title: Monitoring Well Development

1.0 Purpose and Applicability

This SOP describes the methods used for developing monitoring wells after original installation and prior to use of the well for obtaining water level measurements or water quality samples. Development should not be confused with purging, the purpose of which is to evacuate the monitoring well system of stagnant water which may not be representative of the aquifer. For purging procedures refer to ENSR SOP No. 7130, Ground-Water Sample Collection from Monitoring Wells.

Monitoring well development and/or rehabilitation are necessary to ensure that complete hydraulic connection is made and maintained between the well and the aquifer material surrounding the well screen and packing materials. Development is necessary after original installation of a monitoring well to (1) reduce the compaction and inter-mixing of grain sizes produced during drilling; (2) to increase the porosity and permeability of the artificial filter pack by removing the finer grain-size fraction introduced near the screen by drilling and well installation; and (3) to remove any foreign drilling fluids that coat the borehole or that may have invaded the adjacent natural formation.

This procedure applies to monitoring wells in which siltation has been determined to have occurred. After a well has been installed for some period of time (ranging from months to years), siltation of the well may occur and rehabilitation will be necessary to re-establish complete hydraulic connection with the aquifer.

2.0 Definitions

Note: Equipment components are defined in Section 7.0 of this SOP.

Bridging: A condition within the filter pack outside the well screen whereby the smaller particles are wedged together in a manner that causes blockage of pore spaces.

Hydraulic Conductivity: A characteristic property of aquifer materials which describes the permeability of the material to a particular fluid (usually water).

Hydraulic Connection: A properly installed and developed monitoring well should have a complete hydraulic connection with the aquifer. The well screen and filter material should not provide any restriction to the flow of water from the aquifer to the well.

Permeability Test: Used to determine the hydraulic conductivity of the aquifer formation near a well screen. Generally conducted by displacing the water level in a well and monitoring the rate of recovery of the water level as it returns to equilibrium. Various methods of analysis are available to calculate the hydraulic conductivity from these data.

Screened Interval: That portion of a monitoring well that is open to the aquifer.

Static Water Level: The water level in a well that represents an equilibrium condition when the aquifer is not being stressed (no nearby withdrawal or injection of water). Since the ground water conditions are generally dynamic, static is a condition that holds true only for short periods of time (anywhere from minutes to years depending on cultural and climatic influences).

Well Surging: That process of moving water in and out of a well screen to remove fine sand, silt and clay size particles from the adjacent formation.

Well Purging: The process of removing water from a well to allow in situ formation water to enter the well. Generally thought of in terms of removing standing water from a well prior to the collection of water samples for quality determination, the process also is conducted to remove suspended particles from the well after well surging.

Well Screen: That portion of the well casing material that is perforated in some manner so as to provide a hydraulic connection to the aquifer. Typically a well screen has slots but holes, slits, louvers, and other perforations can, in some situations, be used.

3.0 Health and Safety Considerations

Monitoring well development may involve chemical hazards associated with materials in the soil or aquifer being explored; and always involves physical hazards associated with the heavy equipment that may be used for various development techniques. When wells are to be installed and developed in locations where the aquifer and/or overlying materials may contain chemical hazards, a Health and Safety Plan must be prepared and approved by the Health and Safety Officer before field work commences.

In addition, the following protective measures are always required:

- all persons within 50 feet of a drill rig must wear hard hats and safety shoes. Hearing protection should be provided during periods of excessive noise; and
- personnel who are not directly involved in overseeing, inspecting or performing the drilling and well installation will remain at least 100 feet away from the drill rig.

4.0 Quality Assurance Planning Considerations

The appropriate development method will be selected for each project on the basis of the circumstances, objectives and requirements of that project. Further, some states and EPA regions have promulgated comprehensive guidelines for ground water monitoring and subsurface investigation procedures. The provisions of this SOP will be adapted to these project-specific requirements in the Quality Assurance Project Plan (QAPP). Each QAPP will describe the specific method(s) to be used and the rationale, including trade-offs associated with the nature of the aquifer formation, chemical analytical objectives, and client or agency requirements.

5.0 Responsibilities

Development of new monitoring wells is the responsibility of the geologist or hydrogeologist involved in the original installation of the well. The geologist may, in fact, contract with the well driller to develop new wells under the geologist's guidance and oversight. Records of well development methods and results are to be kept by the geologist.

Any person using existing monitoring wells for any purpose is responsible for verifying the original well construction details and determining if a well requires rehabilitation.

6.0 Training/Qualifications

Each ENSR employee who develops a monitoring well for an ENSR project will have been trained by an experienced ENSR geologist in the specific procedure used.

7.0 Supporting Materials

The following list identifies the types of equipment which may be used to develop monitoring wells. Exact equipment needs will be well-specific and will depend upon the diameter of the well, the depth to the static water level and other factors.

7.1 Surge Block

A surge block consists of a rubber (or leather) and metal plunger attached to rod or pipe of sufficient length to reach the bottom of the well. Well drillers usually can provide surge blocks for large diameter wells (greater than 6 inches). Surge blocks for smaller diameter wells can be constructed easily of materials readily accessible in any hardware store. A recommended design is shown in Figure 1. To reduce cross-contamination of monitoring wells, a new plunger generally is used in each well to be developed and the rod is decontaminated in accordance with procedures in ENSR SOP 7600, Decontamination of Equipment.

7.2 Pump

A pump is necessary to remove large quantities of silt-laden ground water from a well after using the surge block. In some situations, the pump alone is used to both surge the well and remove the fines. Since the purpose of well development is to remove suspended solids from a well, the pump must be capable of moving some solids without damage. The preferred pump is a centrifugal because of its ability to pump solids, but a centrifugal pump will work only where the depth to static ground water is less than approximately 25 feet. In deep ground water situations, a positive-displacement pump such as a submersible or bladder pump will be necessary.

7.3 Bailer

A bailer is to be used to purge silt-laden water from wells after using the surge block. In some situations, the bailer can be used to surge a well but the use of a bailer for surging is not recommended. The bailer is to be used for purging in situations where the depth to static water is greater than 25 feet and the silt loading is greater than that which can be handled by positive-displacement pumps.

7.4 Compressed Gas

Compressed gas, generally nitrogen, can be used to both surge and purge a monitoring well. A nitrogen tank is used to inject gas at the bottom of the water column, driving sediment-laden water to the surface. Compressed gas can also be used for "jetting" - a process by which the gas is directed at the slots in the well screen to cause turbulence (thereby disturbing fine materials in the adjacent filter pack). Compressed gas is not limited to any depth range.

The hose or pipe which will be installed in the well for jetting should be equipped with a horizontal (side) discharge nozzle and one or more small holes in the bottom of the hose to enhance the lifting of sediment during jetting.

Since the compressed gas will be used to "lift" water from the monitoring well, provisions must be made for controlling the discharge from contaminated wells. This is generally accomplished by attaching a "tee" discharge to the top of the casing and providing drums to contain the discharged water. Gas-lifting must never be done in contaminated wells without providing discharge control apparatus.

7.5 Decontamination Equipment

Standard equipment for decontaminating field apparatus in accordance with ENSR SOP 7600 will be used to decontaminate all equipment used to develop monitoring wells.

7.6 Purge Water and Sediment Disposal

The QAPP must specify the means for disposing of purged sediment-laden water. In most cases, disposal of this material will follow the methods used in the original installation of the borehole. If soil and/or ground water contamination conditions in a well have changed, it may be necessary to specify new disposal methods for wells that are being re-developed.

7.7 Monitoring Well Construction Details

A copy of the original Monitoring Well Construction Detail form for the well to be developed must be obtained from the project manager. This form provides critical information regarding the construction of the monitoring well and must be in the possession of the well development crew so that pertinent well construction details, such as total depth, are known.

7.8 Supporting SOPs

- 7130 - Ground-Water Sample Collection from Monitoring Wells
- 7220 - Monitoring Well Construction and Installation
- 7600 - Decontamination of Equipment
- 7720 - Rising-Head/Falling-Head Permeability Testing

8.0 Procedure for Well Development

8.1 General Procedure

8.1.1 Conduct a permeability test as described in ENSR SOP 7720 to determine the hydraulic conductivity of the screened interval. The results of this test, along with other tests conducted during the development process, will be used to evaluate the success of the development.

8.1.2 Water is caused to move in and out through the monitoring well screen to move silt and clay particles out of the filter pack around the well screen and into suspension within the well. Water movement is effected using a surge block, bailer, or a compressed gas. In some situations, pumping water may effect satisfactory development, but pumping alone is not generally recommended.

8.1.3 The sediment-laden water is removed from the monitoring well using a pump, bailer, or air compressor.

8.1.4 Surging of the well is continued until the water removed is essentially free of suspended silt and clay particles. During the surging/purging cycles, a permeability test should be performed as described in ENSR SOP 7720 to monitor and evaluate the development process.

8.1.5 Generally, a permeability test as described in ENSR SOP 7720 is used to confirm that a reliable hydraulic connection has been established (or re-established) between the well and the surrounding aquifer material.

8.2 Selection of a Specific Procedure

The construction details of the well can be used to initially define the method of purging a well with due consideration being given to the level of contamination.

The criteria for selecting a well development method include well diameter, total well depth, static water depth, screen length, the likelihood and level of contamination, and the type of geologic formation adjacent to the screened interval.

The limitations, if any, of a specific procedure are discussed within each of the following procedures.

Methods that involve placing water into the well may be objectionable to some state and federal agencies. In such cases the surge block procedure may be preferable over the pumping procedure.

8.3 Specific Procedure: Surge Block

8.3.1 A surge block effectively develops most monitoring wells. If the geologic layering in the screened interval includes permeable and impermeable layers (e.g., gravels and clays), it is possible that surging could remove fines from the impermeable layers and force them into the permeable layers. This problem can be minimized by using fewer surging cycles, using a surge block which is looser fitting and/or increasing the purging volume or time of development.

8.3.2 Construct a surge block using the design in Figure 1 as a guide. Specific materials will depend upon the diameter of well to be developed. The diameter of the flexible rings must be sufficient to cause a tight seal within the well casing, and the rods must be of sufficient length to reach to the bottom of the monitoring well.

8.3.3 Insert the surge block into the well and lower it slowly to the level of static water. Start the surge action slowly and gently above the well screen using the water column to transmit the surge action to the screened interval. A slow initial surging, using plunger strokes of 3 to 5 feet, will allow material which is blocking the screen to separate and become suspended.

8.3.4 After a number (5 to 10) of plunger strokes, remove the surge block and purge the well using a pump or bailer. The returned water should be heavily laden with suspended silt and clay particles. As development continues, slowly increase the depth of surging to the bottom of the well screen. For monitoring wells with long screens (greater than 10 feet) surging should be undertaken along the entire screen length in short intervals (2 to 3 feet) at a time.

8.3.5 Continue this cycle of surging and purging until the water yielded by the well is free of visible suspended material.

8.4 Specific Procedure: Pump

8.4.1 Well development using only a pump is most effective in those monitoring wells that will yield water continuously. Effective development cannot be accomplished if the pump has to be shut off to allow the well to recharge.

8.4.2 Set the intake of the pump in the center of the screened interval of the monitoring well.

8.4.3 Pump a minimum of three well volumes of water from the well while using the intake hose of the pump as a plunger. The motion of the intake hose will act to a limited extent as a surge block.

8.4.4 Occasionally, where appropriate, use the pump to fill the monitoring well to the top of the casing and allow the water level to decline to the static level, thereby forcing water back into the formation. This action will cause water to exit the well screen and reduce the bridging of materials caused by water flowing in one direction through the well screen while pumping.

The water used to fill the monitoring well should be the same water removed from the well during the previous pumping cycle. The sediment previously pumped from the well must be removed from the water prior to re-introduction to the well. A steel drum can be used as a sediment-settling vessel.

8.4.5 Continue pumping water into and out from the well until sediment-free water is obtained.

8.5 Specific Procedure: Bailer

8.5.1 Lower the bailer into the screened interval of the monitoring well.

8.5.2 Using long, slow strokes, raise and lower the bailer in the screened interval simulating the action of a surge block.

8.5.3 Periodically bail standing water from the well to remove silt and clay particles drawn into the well.

8.5.4 Continue surging the well using the bailer and bailing water from the well until sediment-free water is obtained.

8.6 Specific Procedure: Compressed Gas (Nitrogen)

8.6.1 Although the equipment used to develop a well using this method is more difficult to handle and use, well development using compressed gas for jetting is considered to be a very effective method. This method also is the most generally applicable because it is not limited by well depth, well diameter or depth to static water, but caution must be exercised in highly permeable formations not to inject gas into the formation.

8.6.2 Lower the gas line from the gas cylinder into the well, setting it near the bottom of the screened interval. Install the discharge control equipment at the well head.

8.6.3 Set the gas flow rate to allow continuous discharge of water from the well. The discharge will contain suspended clay and silt material.

8.6.4 At intervals during gas-lifting, especially when the discharge begins to contain less suspended material, shut off the air flow and allow the water in the well to flow out through the screened interval to disturb any bridging that may have occurred. Re-establish the gas flow when the water level in the well has returned to the pre-development level.

8.6.5 Jetting of the screened interval also can be done during gas-lifting of water and sediment from the well. This is accomplished by using a lateral-discharge nozzle on the gas pipe or hose and slowly moving the nozzle along the length of the screened interval. Jetting should be done beginning at the bottom of the well screen and moving slowly upwards along the screened interval. To enhance gas lifting of sediment, occasionally raise the discharge nozzle into the cased portion of the well and discharge sediment-laden water.

8.6.6 Continue gas-lifting and/or jetting until the water returned in the air stream is free from suspended material.

9.0 Quality Control Checks

A well has been successfully developed when one or more of the following criteria are met:

- the well yields only clear, sediment-free water.
- two or more permeability tests in accordance with ENSR SOP 7720 yield repeatable hydraulic conductivity values.
- the original depth of the well, as described on the Monitoring Well Construction Detail form in ENSR SOP 7220, is clear of sediment and that depth is maintained for some period of time (longer than hours, probably less than one year).

10.0 Documentation

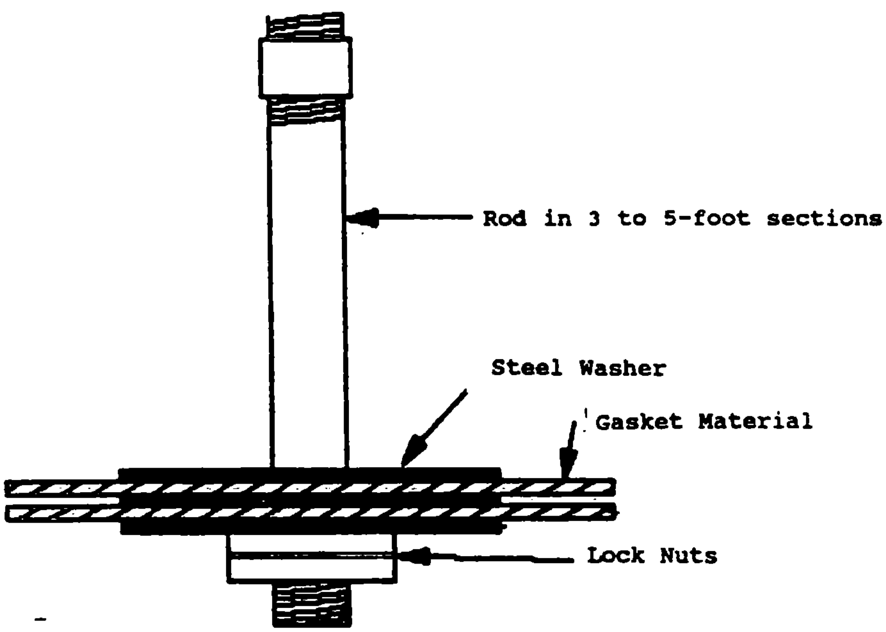
The Monitoring Well Development Record (Figure 2) will be completed by the geologist or hydrogeologist conducting the development. In addition, a field log book should be maintained detailing any problems or unusual conditions which may have occurred during the development process. Any inability to return the well to the original specifications will be noted on the original copy of the Monitoring Well Construction Detail form and on the Monitoring Well Development Record (Figure 2).

All documentation will be retained in the project files following completion of the project.

Figure 1

SURGE BLOCK DESIGN

Steel washers should be 1/2" to 3/4" smaller diameter than the well ID. Gasket can be rubber or leather and should be the same diameter or 1/8" smaller than the well diameter to compensate for swelling of the leather. Rod can be steel, fiberglass, or plastic but must be strong and lightweight.



NOT TO SCALE

ENSR CONSULTING & ENGINEERING

Figure 1
Surge Block Design

TMC	11/10/88	SOP 7221

ENSR

MONITORING WELL DEVELOPMENT RECORD

DATE: ______________________ WELL I.D.: ______________________

PROJECT NAME: ______________________ LOCATION: ______________________

PROJECT NUMBER: ______________________ DEVELOPER: ______________________

☐ ORIGINAL DEVELOPMENT ☐ REDEVELOPMENT ORIGINAL DEVELOPMENT DATE: __________

WELL DATA

Well Diameter	
Total Well Depth	
Depth to Top of Screen	
Depth to Bottom of Screen	
Depth to Static Water Level	

Geology at Screened Interval	
Likely Contaminants	
Purge Water and Sediment Disposal Method	

DEVELOPMENT METHOD	PURGING METHOD	PERMEABILITY TEST RESULTS

ACCEPTANCE CRITERIA

Signature ______________________ Date __________

M890322

Figure 2

ENSR

MONITORING WELL DEVELOPMENT RECORD

DATE: ______________________ WELL I.D.: ______________________

PROJECT NAME: ______________________ LOCATION: ______________________

PROJECT NUMBER: ______________________ DEVELOPER: ______________________

☐ ORIGINAL DEVELOPMENT ☐ REDEVELOPMENT ORIGINAL DEVELOPMENT DATE: __________

WELL DATA

Well Diameter	
Total Well Depth	
Depth to Top of Screen	
Depth to Bottom of Screen	
Depth to Static Water Level	

Geology at Screened Interval	
Likely Contaminants	
Purge Water and Sediment Disposal Method	

DEVELOPMENT METHOD	PURGING METHOD	PERMEABILITY TEST RESULTS

ACCEPTANCE CRITERIA

Signature ______________________ Date __________

M890322

STANDARD OPERATING PROCEDURE

Number: 7510 Date of Issue: March 12, 1984

Title: Packaging and Shipment of Samples

Organizational Acceptance	Authorization	Date
Originator	[illegible]	[illegible] 84
Department Manager	[illegible]	3/13/84
Divisional Manager		
Group Quality Assurance Officer		
Other		

Revisions	Changes	Authorization	Date
1	• Sect. 4.11 Chain-of-Custody procedure for hinged coolers added • Miscellaneous rewording for clarification	[illegible] [illegible]	9-19-86 10-13-86

1.0 Applicability

This Standard Operating Procedure (SOP) is concerned with procedures associated with the packaging and shipment of samples. Two general categories of samples exist: environmental samples consisting of air, water and soil; and waste samples which include non-hazardous solid wastes and hazardous wastes as defined by 40 CFR Part 261.

2.0 Responsibilities

It is the responsibility of the project manager to assure that the proper packaging and shipping techniques are utilized for each project. The site operations manager shall be responsible for the enactment and completion of the packaging and shipping requirements outlined in the project specific sampling plan. The site operations manager shall be responsible to research, identify and follow all applicable U.S. Department of Transportation (DOT) regulations regarding shipment of materials classified as waste.

3.0 General Method

The objective of sample packaging and shipping protocol is to identify standard procedures which will minimize the potential for sample spillage or leakage and maintain field sampling program compliance with U.S. EPA and U.S. DOT regulations.

The extent and nature of sample containerization will be governed by the type of sample, and the most reasonable projection of the sample's hazardous nature and constituents. The EPA regulations (40 CFR Section 261.4(d)) specify that samples of solid waste, water, soil or air, collected for the sole purpose of testing, are exempt from regulation under the Resource Conservation and Recovery Act (RCRA) when all of the following conditions are applicable:

A. Samples are being transported to a laboratory for analysis;
B. Samples are being transported to the collector from the laboratory after analysis;
C. Samples are being stored (1) by the collector prior to shipment for analyses, (2) by the analytical laboratory prior to analyses, (3) by the analytical laboratory after testing but prior to return of sample to the collector or pending the conclusion of a court case.

Qualification for categories A and B above require that sample collectors comply with U.S. DOT and U.S. Postal Service (USPS) regulations or comply with the following items if U.S. DOT and USPS regulations are found not to apply:

The following information must accompany all samples and will be entered on a sample specific basis on chain of custody records:

- sample collector's name, mailing address and telephone number,
- analytical laboratory's name, mailing address and telephone number,
- quantity of sample,
- date of shipment,
- description of sample, and

in addition, all samples must be packaged so that they do not leak, spill or vaporize.

4.0 General Methods

4.1 Place plastic bubble wrap matting over the base and bottom corners of each cooler or shipping container as needed to manifest each sample.

4.2 Obtain a chain of custody record as shown in Figure 1 and enter all the appropriate information as discussed in Section 3.0 of this SOP. Chain of custody records will include complete information for each sample. One or more chain of custody records shall be completed for each cooler or shipping container as needed to manifest each sample.

4.3 Wrap each sample bottle individually and place standing upright on the base of the appropriate cooler, taking care to leave room for some packing material and ice or equivalent. Rubber bands or tape should be used to secure wrapping, completely around each sample bottle.

4.4 Place additional bubble wrap and/or styrofoam pellet packing material throughout the voids between sample containers within each cooler.

4.5 Place ice or cold packs in heavy duty zip-lock type plastic bags, close the bags, and distribute such packages over the top of the samples.

4.6 Add additional bubble wrap/styrofoam pellets or other packing materials to fill the balance of the cooler or container.

4.7 Obtain two pieces of chain of custody tape as shown in Figure 2 and enter the custody tape numbers in the appropriate place on the chain of custody form. Sign and date the chain of custody tape.

4.8 To complete the chain of custody form enter the type of analysis required for each sample, by container, under the "ANALYSES" section. Under the specific analysis enter the quantity/volume of sample collected for each corresponding analysis.

If shipping the samples where travel by air or other public transportation is to be undertaken, sign the chain of custody record thereby relinquishing custody of the samples. Relinquishing custody should only be performed when directly transmitting custody to a receiving party or when transmitting to a shipper for subsequent receipt by the analytical laboratory. Shippers should not be asked to sign chain of custody records.

4.9 Remove the last copy from the chain of custody record and retain with other field notes. Place the original and remaining copies in a zip-lock type plastic bag and place the bag on the top of the contents within the cooler or shipping container.

4.10 Close the top or lid of the cooler or shipping container and with another person rotate/shake the container to verify that the contents are packed so that they do not move. Improve the packaging if needed and reclose.

When transporting samples by automobile to the laboratory, and where periodic changes of ice are required, the cooler should only be temporarily closed so that reopening is simple. In these cases, chain of custody will be maintained by the person transporting the sample and chain of custody tape need not be used. If the cooler is to be left unattended, then chain of custody procedures should be enacted.

4.11 Place the chain of custody tape at two different locations on the cooler or container lid and overlap with transparent packaging tape. For coolers with hinged covers, if the hinges are attached with screws, chain of custody tape should also be used on the hinge side.

4.12 Packaging tape should be placed entirely around the sample shipment containers. A minimum of one to two full wraps of packaging tape will be placed at at least two places on the cooler. Shake the cooler again to verify that the sample containers are well packed.

4.13 If shipment is required, transport the cooler to an overnight express package terminal or arrange for pickup. Obtain copies of all shipment records as provided by the shipper.

4.14 If the samples are to travel as luggage, check with regular baggage.

4.15 Upon receipt of the samples, the analytical laboratory will open the cooler or shipping container and will sign "received by laboratory" on each chain of custody form. The laboratory will verify that the chain of custody tape has not been broken previously and that the chain of custody tape number corresponds with the number on the chain of custody record. The analytical laboratory will then forward the back copy of the chain of custody record to the sample collector to indicate that sample transmittal is complete.

5.0 Documentation

As discussed in Section 4.0 the documentation for supporting the sample packaging and shipping will consist of chain of custody records and shipper's records. In addition a description of sample packaging procedures will be written in the field log book. All documentation will be retained in the project files following project completion.

0908J

CHAIN OF CUSTODY RECORD

Client/Project Name	Project Location	ANALYSES							
Project No.	Field Logbook No.								
Sampler: (*Signature*)	Chain of Custody Tape No.								

Sample No./ Identification	Date	Time	Lab Sample Number	Type of Sample								REMARKS

Relinquished by: (*Signature*)	Date	Time	Received by: (*Signature*)	Date	Time
Relinquished by: (*Signature*)	Date	Time	Received by: (*Signature*)	Date	Time
Relinquished by: (*Signature*)	Date	Time	Received for Laboratory: (*Signature*)	Date	Time
Sample Disposal Method:			Disposed of by: (*Signature*)	Date	Time

SAMPLE COLLECTOR	ANALYTICAL LABORATORY	ENSR
ERT - A Resource Engineering Company 696 Virginia Road Concord, MA 01742 617-369-8910		Nº 1663

1974 3 84

Figure 1

ENSR STANDARD OPERATING PROCEDURE

Number: 7600 Date of Issue: 1st Quarter, 1984

Title: Decontamination of Equipment

Organizational Acceptance	Authorization	Date
Originator	Charles E Martin	3/2/84
Department Manager	Arthur L Frame	3/2/84
Divisional Manager	Elaine Moore	3-2-84
Group Quality Assurance Officer	Scott M. Whittemore	3/2/84
Other		

Revisions	Changes	Authorization	Date
1	Update	SMW	3/2/84
		CEM	3/2/84
		AGL	3/2/84
		EMc	3-2-84

STANDARD OPERATING PROCEDURE

Title: Decontamination

Date: 1st Qtr 1984
Number: 7600
Revision: 1

1.0 General Applicability

This SOP describes the methods to be used for the decontaminization of all field equipment which becomes potentially contaminated during a sample collection task. The equipment may include split spoons, bailers, trowels, shovels, hand augers, or any other type of equipment used during field activities.

Decontamination is performed as a quality assurance measure and a safety precaution. It prevents cross-contamination between samples and also helps to maintain a clean working environment for the safety of all field personnel involved, including the environment.

Decontamination is mainly achieved by rinsing with liquids which include: soap and/or detergent solutions, tap water, deionized water, and methanol. Equipment will be allowed to air dry after being cleaned or may be wiped dry with chemical free cloths or paper towels if immediate re-use is needed.

The frequency of equipment use, dictates that most decontamination be accomplished at each sampling site between collection points. Waste products produced by the decontamination procedures such as waste liquids, solids, rags, gloves, etc. will be collected and disposed of properly based on the nature of contamination. All cleaning materials and wastes should be stored in a central location so as to maintain control over the quantity of materials used and/or produced throughout the study.

2.0 Responsibilities

It is the primary responsibility of the site operations manager to assure that the proper decontamination procedures are followed and that all waste materials produced by decontamination are properly stored and disposed of.

It is the responsibility of the project safety officer to draft and enforce safety measures which provide the best protection for all persons involved directly with sampling and/or decontamination.

It is the responsibility of any subcontractors (i.e., drilling contractors) to follow the proper, designated decontamination procedures that are stated in their contracts and outlined in the Project Health and Safety Plan.

It is the responsibility of all personnel involved with sample collection or decontamination to maintain a clean working environment and to ensure that any contaminants are not negligently introduced to the environment.

3.0 Supporting Materials

- cleaning liquids: soap and/or detergent solutions, tap water, deionized water, methanol
- personal safety gear (defined in Project Health and Safety Plan)
- chemical-free paper towels
- disposable gloves
- waste storage containers: drums, boxes, plastic bags
- cleaning containers: plastic buckets, galvanized steel pans
- cleaning brushes

4.0 Methods or Protocol for Decontamination

4.1 General Procedures

4.1.1 The extent of known contamination will determine to what extent the equipment needs to be decontaminated. If the extent of contamination cannot be readily determined, cleaning should be done according to the assumption that the equipment is highly contaminated until enough data are available to allow assessment of the actual level of contamination.

4.1.2 Adequate supplies of all materials must be kept on hand. This includes all rinsing liquids and other materials listed in Section 3.0.

4.1.3 The standard procedures listed in the following section can be considered the procedure for full field decontamination. If different or more elaborate procedures are required for a specific project, they will be spelled out in the project work plan. Such variations in decontamination may include following all, just part, or an expanded scope of the decontamination procedure stated herein.

4.2 Standard Procedures

4.2.1 Remove any solid particles from the equipment or material by brushing and then rinsing with available tap water. This initial step is performed to remove gross contamination.

4.2.2 Wash equipment sampler with the soap or detergent solution.

4.2.3 Rinse with tap water

4.2.4 Rinse with deionized water

4.2.5 Rinse with methanol

4.2.6 Repeat entire procedure or any parts of the procedure if necessary

4.2.7 Allow the equipment or material to air dry before re-using

4.2.8 Dispose of any soiled materials in the designated disposal container

5.0 Specific Decontamination Procedures

5.1 Submersible Pump

5.1.1 Applicability

This procedure will be used to decontaminate submersible pumps between ground-water sample collection points and at the end of each day of use.

5.1.2 Materials

- o plastic-nalgene upright cylinder
- o 5-10 gallon plastic water storage containers
- o methanol and dispenser bottle
- o deionized water and dispenser bottle
- o chemical free paper towels

5.1.3.1 During decontamination the submersible pump will be placed on a clean surface or held away from ground.

5.1.3.2 When removing the submersible pump from each well the power cord and discharge line will be wiped dry using chemical-free disposable towels.

5.1.3.3 Clean the upright plastic-nalgene cylinder with first a methanol and then a deionized water rinse, wiping the free liquids after each.

5.1.3.4 Reverse pump backwashing all removable residual water present in the pump tubing. The pump should be shut off as soon as intermittent flow is observed from the reverse discharge.

5.1.3.5 Rinse the stainless steel submersible down hole pump section with a liberal application of methanol and wipe dry.

5.1.3.6 Place the submersible pump section upright in the cylinder and fill the cylinder with tap water, adding 50-100 ml of methanol for every one liter of water.

5.1.3.7 Activate the pump in the forward mode withdrawing water from the cylinder.

5.1.3.8 Continue pumping until the water in the cylinder is pumped down and air is drawn through the pump. At this time air pockets will be observed in the discharge line. Shut off the pump immediately.

5.1.3.9 Remove the pump from the cylinder and place the pump in the reverse mode allowing that all removable water be discharged on to the ground surface as discussed in Step 2.

5.1.3.10 Using the water remaining in the cylinder, rinse the sealed portion of the power chord and discharge tube by pouring the water carefully over the coiled lines.

5.1.3.11 When reaching the next monitoring well place the pump in the well casing and wipe dry both the power and discharge lines with a clean paper towel as the pump is lowered.

5.1.4 Quality Assurance

To assure that decontamination is complete, field blank samples shall be collected using the cleaned submersible pump. These field blanks will be subsequently analyzed for the parameters of interest with respect to the ground water.

The procedure for collecting the field blanks will comprise using the pump to withdraw the tap water used for decontamination, from the plastic cylinder to sample containers. This field blank sample collection procedure shall only be performed after the materials to be used have been decontaminated.